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Studying terns to efficiently conserve their riverine habitats

Raziskovanje navadne čigre z namenom učinkovitega varstva njenega rečnega habitata

Interreg
SLOVENIJA – HRVAŠKA
SLOVENIJA – HRVATSKA
Evropska unija | Evropski sklad za regionalni razvoj
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ČIGRA
Očuvanje populacija čigre u porječju Save i Drave“
Ohranjanje populacij čigre v porečju Save in Drave

Rivers are among the most endangered habitats in Europe. Large rivers, meandering and carrying substrate along their route, create extensive gravel and sandy islands, oxbow lakes, side-arms, areas with shallow water, steep gravel and sand banks. Such variety of features creates a rich habitat for breeding and foraging of terns, plovers, storks, herons, kingfishers, sand martins and numerous other waterbirds, as well as attracts raptors like the White-tailed Eagle. However, pristine and free-flowing rivers are unfortunately now part of history. Large European rivers are heavily impacted by hydropower dams, river regulation, channelling and extraction of sediment. These activities changed maps of many European lowlands but, more importantly, endangered the whole ecosystem connected to large rivers. Hydropower dams affect habitats in many ways: the most obvious is by creating reservoirs with concrete banks on an area where rivers used to flow freely. But the effect of dams continues downstream: waterflow in natural riverbeds decreases, groundwater levels change, sediment transportation is blocked and hydropeaking causes artificial flood waves. The river no longer functions as a corridor.

Many waterbird species are now seriously threatened, either globally or at a national or continental level. The Little Tern has already disappeared from Slovenian rivers and the last colony on the Drava River in Croatia is severely threatened by frequent flooding. The Common Tern readily accepts artificial breeding islands and rafts, so it is in a somewhat better situation. Today, complete breeding populations of Common Tern in several European countries nest at artificial sites and depend on their regular management. In Slovenia, DOPPS started to manage tern breeding islands already in the early 1980s after the loss of natural habitats along the Drava River through the creation of Lake Ptuj. In Croatia, such activities started in the 2000s. However, artificial habitats can act as an ecological trap, as they require constant management activities. Everyone who has witnessed how quickly artificial islands are overgrown by vegetation can imagine what would happen if their management ceased even for a single year.

Terns do need our help – not only through regular management of their nesting sites but, more importantly, through re-establishing and conserving their natural habitats. Here, as in many other cases, nature protection relies on the so-called "flagship species". There have been several projects and initiatives in Slovenia and Croatia over the past years, the ultimate goals of which were not only to protect Common or Little Terns, but to protect their natural freshwater habitats. These habitats provide breeding, spawning or foraging sites and migration corridors for a rich variety of other bird, mammal, fish and insect species, in addition to supporting numerous native plant species.

Croatian and Slovenian ornithologists, already involved in the study and protection of terns, joined their efforts in the Interreg V-A SI-HR ČIGRA project. Its activities are aimed to improve breeding opportunities along the Sava and Drava rivers, as well as to raise awareness about the need to preserve remaining natural habitats along these rivers and to re-establish them wherever still possible.

This thematic issue presents some of the results achieved during the project, building on studies and conservation activities from previous decades. Breeding colonies had been monitored in both countries for years, but this project brought first data on habitat use by breeding terns. It turned out that the majority of foraging occurred at specific stretches of the Sava and Drava Rivers, highlighting that, although artificial lakes and gravel pits can constitute adequate nesting habitat, stretches of natural rivers are important for terns feeding during the breeding season. The project also helped to understand the connection between Slovenian and Croatian colonies, through tracking tern movements and analyzing their genetic diversity and shared haplotypes. The study brought some surprises: one of the first birds tagged in Croatia was an incubating adult female, ringed as chick back in 2014 at Škocjanski zatok. This indicated that coastal and inland Slovenian and Croatian breeding sites are more connected than previously thought. The cooperation between Slovenian and Croatian ornithologists, supported by other stakeholders in the effort to protect inland Common Terns and their habitats, resulted in a transboundary Action Plan for conserving inland tern populations. We hope that its adoption and implementation in both countries will ensure long-term protection of Common Terns and their habitats.

* * *

Reke sodijo med najbolj ogrožene habitate v Evropi. Velike reke vzdolž svojega toka meandrirajo, prenašajo usedline, gradijo prodnate in peščene otoke, okljuke, mrtvice, plitvine, strma in peščena nabrežja. Takšna rečna raznolikost ustvarja bogat ekosistem, primeren za razmnoževanje in prehranjevanje čiger, prodnikov, štorkelj, čapelj, vodomcev, breguljk in drugih vodnih ptic. Privablja tudi ujede, kot na primer belorepce. Žal so danes neokrnjene reke že zgodovina. Velike evropske reke so zaradi jezov hidroelektrarn, rečnih regulacij, kanalizacij in izkoriščanja prodnega materiala že močno okrnjene. Vsi ti posegi so v nižinskih predelih dodobra spremenili zemljevid Evrope in, kar je še bolj pomembno, ogrozili ekosistem velikih rek. Jezovi hidroelektrarn spreminjajo okolje večplastno: najbolj opazna so akumulacijska jezera z betonskimi brežinami, ki nastanejo na območjih, kjer so reke nekoč tekle neutesnjene. A učinki jezov se poznajo tudi po toku vode navzdol: zmanjšujejo rečni pretok, spreminjajo nivo podtalnice in zaustavljajo prenos sedimenta, medtem ko odpiranje zapornic povzroča nenaravne poplavne valove. Zaradi vse teh sprememb so reke izgubile pomen naravnih koridorjev.

Številne vodne vrste ptic so danes globalno, regionalno ali nacionalno ogrožene. Mala čigra je s prodišč slovenskih rek že izginila. Zadnja kolonija na reki Dravi na Hrvaškem je zaradi pogostih poplav kritično ogrožena.

Navadna čigra za gnezdenje zlahka sprejme tudi umetno narejene otoke in splave, zato je stopnja njene ogroženosti nekoliko manjša kakor pri mali čigri. V številnih evropskih državah danes navadna čigra gnezdi le še na umetnih gnezdiščih, ki so povsem odvisna od človekovega upravljanja. V Sloveniji je DOPPS začel z upravljanjem umetnih gnezdišč za čigre že v zgodnjih 80ih letih prejšnjega stoletja, ko so čigre na Dravi, tudi zaradi nastanka Ptujskega jezera, izgubile velik del svojega naravnega habitata. Na Hrvaškem so s podobnimi aktivnostmi začeli v začetku tega stoletja. A umetna gnezdišča so lahko tudi ekološke pasti, če jih ljudje ne vzdržujejo redno. Vsakdo, ki ve, kako hitro se umetna gnezdišča zarastejo, ve tudi, kaj bi se zgodilo, če ljudje umetnega gnezdišča ne bi več redno vzdrževali.

Čigre potrebujejo našo pomoč – ne samo v obliki rednega vzdrževanja gnezdišč. Še bolj potrebujejo pomoč v obliki varovanja in renaturacije naravnih habitatov. Kot tudi marsikje drugod je varovanje zelo odvisno od tako imenovanih "zastavonoš" (flagship species). V preteklih letih je bilo v Sloveniji in na Hrvaškem že več projektov in pobud za ohranitev navadne in male čigre v naravnih habitatih celinskih voda. Takšni habitati omogočajo gnezdenje, drstenje, prehranjevanje in selitev tudi številnim drugim vrstam ptic, sesalcem, ribam in žuželkam. Območja so pomembna tudi kot rastišča številnih avtohtonih rastlin.

Hrvaški in Slovenski ornitologi, ki so že več let aktivni na področju raziskovanja in varovanja čiger, so v projektu Interreg V-A SI-HR »ČIGRA« združili vse svoje moči. Namen projektnih aktivnosti je bil čigram izboljšati gnezditvene možnosti vzdolž reke Save in Drave. Hkrati je bil namen projekta tudi povečati zavedanje ljudi o pomenu ohranjanja naravnih območij rek in o potrebi renaturacije novih rečnih odsekov.

V tematski številki Acrocephalusa o čigrah je predstavljenih nekaj rezultatov, ki smo jih zbrali že med uresničevanjem predhodnih projektov in tudi tega projekta. V obeh državah že več let spremljamo stanje čiger na gnezditvenih kolonijah, v okviru tega projekta pa smo znanje nadgradili z novimi izsledki s področja izbire habitata. Izkazalo se je, da so poleg umetno narejenih otokov in splavov, ki so pomembni kot gnezdišča, za prehranjevanje čiger zelo pomembni tudi posamezni odseki ohranjenih delov Save in Drave, na katerih se prehranjujejo. S pomočjo rezultatov sledenja in analize genetsko pestrost izbranih osebkov čigre danes tudi bolje razumemo stopnjo povezanosti med slovenskimi in hrvaškimi kolonijami. Raziskava je postregla tudi s presenečenji: ena izmed prvih ujetih samic navadne čigre na Hrvaškem je bila obročkana že leta 2014 v Škocjanskem zatoku. To kaže, da so obalne in celinske čigre iz obeh držav med sabo bolj povezane, kakor smo predvidevali doslej. Sodelovanje med slovenskimi in hrvaškimi ornitologi, ob pomoči drugih deležnikov pri naporih za zavarovanje celinskih čiger in njihovega habitata, je prineslo tudi čezmejni Akcijski načrt za zavarovanje celinske populacije čigre. Upamo, da bo sprejetje in uresničevanje tega dokumenta v obeh državah zagotovilo dolgoročno varstvo navadne čigre in njenega habitata.

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Breeding population dynamics of Common Tern *Sterna hirundo* and associated gull species with overview of conservation management in continental Slovenia

Dinamika gnezditvene populacije navadne čigre *Sterna hirundo* in pridruženih vrst galebov s pregledom naravovarstvenega upravljanja v celinskem delu Slovenije

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An overview of the long-term (1980–2019) population development of colonial Laridae species in continental part of Slovenia, their nest sites at anthropogenic water bodies, and various conservation measures with special focus on Common Tern *Sterna hirundo* along the Slovenian/border part of the Drava River is given. Breeding of these species occurs only on the westernmost fringes of the Pannonian plain, on lowland floodplains of the main rivers of the Danube Basin. Altogether, breeding of Common Tern and Black-headed Gull *Larus ridibundus* was recorded at 11 and 10 sites, respectively. Lake Ptuj is the single site with mixed-species colony residing there in all years of the study period, while at Ormož (two sites) it was established during the early 1990s in the Slovenian territory but moved completely to the Croatian side by the second half of the 2010s. At all other sites, a suitable breeding habitat became available or was provided by management in just a few years, or created only recently. The percentage of Common Tern national population breeding in continental Slovenia was usually well above 50% throughout the 1980s and 1990s (52–136 pairs), while in the last 16 years (77–258 pairs) it ranged between 40.8% and 69.0%. Breeding of Black-headed Gull remains largely limited to continental Slovenia. Overall, continental populations of both species in the last few years have been substantially higher compared to the most of the study period. Long-term trends were estimated as a moderate increase for Common Tern and a strong increase for Black-headed Gull. Since 2006, the Mediterranean Gull *L. melanocephalus* has been a regular breeder at Lake Ptuj (up to 28 pairs), the only such site in Slovenia. Three general types of conservation measures implemented at different nesting locations are described in detail: (1) measures to create/increase the total surface of breeding habitat – the construction of new breeding structures, such as artificial islands and nesting rafts, (2) measures to maintain and enhance breeding habitat through recurring management activities, and (3) measures aimed to increase chick/nest survival and improve breeding success.

Key words: Common Tern *Sterna hirundo*, breeding population, conservation management, continental Slovenia
Ključne besede: navadna čigra *Sterna hirundo*, gnezdeča populacija, naravovarstveno upravljanje, celinska Slovenija

1. Introduction

Common Tern *Sterna hirundo* has been strongly affected by habitat destruction (Becker & Ludwigs 2004). Loss of riverine freshwater breeding habitat was the major cause of inland population crashes in Europe during the 19th and 20th centuries (Glutz von Blotzheim & Bauer 1999). Canalization and regulation of rivers, constructions for shipping or power supply, and human recreational activities caused loss of gravel bars and islands for breeding. Consequently, the species now breeds in several countries mainly or exclusively at artificial sites such as gravel pits and, in particular, nesting rafts (Becker & Sudmann 1998, Boschert & Dronneau 1998, Raab 1998, Sudmann *et al.* 2003). The earliest confirmed breeding records for the Common Tern in Slovenia date to 1921 (Reiser 1925). In that year, the species was breeding in the furcation zone of the Drava River at the village of Loka. The next reported breeding was in the years 1977–1979 at a natural side arm of the Drava at Šturmovci (Geister 1995). No further breeding on natural riverbanks or islands has been confirmed in Slovenia. The main cause is the large-scale river canalisation and regulation for hydro-electric power stations. The absence of natural river dynamics resulted in dried river channels and disappearance of gravel habitats (Štumberger 1995). All recently reported nest sites were located on artificial, man-made structures like salt pans (Škornik 1983), artificial islets (Janžekovič & Štumberger 1984), gravel pits (Vogrin 1991a), concrete objects (Bračko 1999), a sandy reservoir islet (Šalamun 2001) and basins of the sugar factory (Štumberger 1982, Denac 2002b, Božič & Denac 2017). Due to often temporal character of such artificial structures, substantial efforts by DOPPS-BirdLife Slovenia were invested to preserve the breeding population of Common Tern in continental Slovenia (Denac 2002, Božič & Denac 2017, Denac & Božič 2018, Denac *et al.* 2019).

Common Tern usually nests colonially, often in association with other tern and gull species (Becker & Ludwigs 2004), which was the case at most Slovenian sites, too. Soon after the mixed Common Tern/Black-headed Gull *Larus ridibundus* colony was established on an artificial island at Lake Ptuj in 1978 (Geister 1995), its breeding became dependent on conservation measures that consider both species. In 2006, the Mediterranean Gull *Larus melanocephalus* started to breed in Slovenia for the first time in a mixed-species colony (Denac & Božič 2009). Its population development in later years profited by conservation measures mainly designed for the Common Tern (Božič & Denac 2019).

The aim of this paper is to give an overview of the long-term population development of colonial Laridae species in continental Slovenia and their nest sites at anthropogenic water bodies, with emphasis on the period since the introduction of more extensive conservation programme. Furthermore, we describe in detail and discuss various conservation measures carried out to preserve breeding populations of all three target species with special focus on Common Tern along the Slovenian/border part of the Drava River.

2. Methods

2.1. Study area

Geographical area of the study comprises landlocked regions of Slovenia with prevailing temperate continental climate. The latter is most pronounced in lowland regions of eastern Slovenia with average annual precipitation of 800–1000 mm. Only the Slovenian Coast with its hinterland in the extreme SW part of the country (the Slovene Istria region), which is largely characterized by coastal sub-Mediterranean climate (Ogrin 1996, Plut 1999), is excluded. In terms of the species studied, this means the colonies breeding at coastal wetlands (Mihelič *et al.* 2019) are beyond the scope of the study. Population figures of these are given only for comparison and overview of the national totals. When available, site toponyms were taken from the national Register of geographical names; otherwise, the established colloquial names are used. The name Ormož Area is used as a common name for two sites, Lake Ormož and Ormož Basins, combined. A detailed description of the colony sites is in Results.

2.2. Data collection

Data considered in this review span the period between 1980 and 2019, when natural nest sites in continental Slovenia no longer existed. In this period, breeding records of the target species were collected by different means, substantially varying between sites and years in terms of the effort invested and accuracy. Data included in the review comprise confirmed breeding records (observations corresponding to a minimum EBCC Breeding Atlas code 10, Hagemeijer & Blair 1997) of individual species at different sites during the period studied, in most cases supplemented by number of breeding pairs. The Yellow-legged Gull *Larus michahellis*, which also breeds in continental Slovenia, was excluded from the overview, as it is here neither a colonial nor associated with other Laridae (Škornik 2018a). Data were obtained systematically using the following methods:

(1) Census of active nests was carried out annually during the two visits of breeding colony in the incubation period of the target species. This method was used at Lake Ptuj for Common Tern and Black-headed Gull in the 2009–2019 period, and Mediterranean Gull in the 2016–2019 period. Visits were planned in a way to coincide with estimated mid- or late phase of incubation period of individual target species, when the number of pairs is presumably the highest (Walsh *et al.* 2015): the first took place in the last 10-day period of April (median 22 Apr) and was aimed at counting Black-headed Gull nests, while during the second, conducted in the last 10-day of May (median 24 May), nests of Common Tern and Mediterranean Gull were counted. Most of the nests of the latter species before 2016 could not be located due to their scarcity and limited ability of observers to identify the clutches. In the 2005–2007 period, only late May-early June visit was carried out (only Common Tern nests counted). During the visits, each nest site was systematically walked and number of nests recorded. Most of the work was carried out by a permanent team of DOPPS ornithologists and the census effort remained fairly constant over the entire period. Due to the late start of the breeding season, two additional visits were made in June 2019. The island on Lake Ormož was visited for survey purpose by DOPPS/Biom team only once per year (late May, early June), as the island colony consisted exclusively or mainly of Common Terns.

(2) Counting of apparently incubating birds with a series of high resolution aerial images of nest sites, captured by drone during a low overflight (c. 20 m above the colony). This method alone was used at Brežice reservoir. As the number of pairs increased, this method was also implemented to supplement the census of active nests at Lake Ptuj in the 2018–2019 period. Drone photography was carried out on or near the same day as the breeding colonies were visited.

(3) Counting of incubating individuals and/or all adult birds present in or near the breeding colony and/or individuals during flush events, with the aid of binoculars and spotting scope from suitable vantage point (one or more) on the shore of the water body. This method was used routinely at Ormož Basins (except 2003), in some of the years between 1997 and 2008 at Lake Ptuj, Lake Ormož before 2015, Mediterranean Gull at Lake Ptuj before 2016, and at several sites with irregular and accidental breeding. Typically, it was implemented several times in the course of the breeding season at regularly occupied sites, and the highest registered number was considered as the number of breeding pairs in a given year (if not decided otherwise due to a specified reason).

(4) Multiple counts of active nests during evenly spaced consecutive visits of nesting location throughout the breeding season. Used as part of a dedicated study of mixed-species colony at Ormož Basins in 2003 (Denac 2006).

(5) Directly from correspondence with experts/local ornithologists (irrespective of the method used, in most cases best expert opinion).

(6) From ornithological literature.

2.3. Trends

Trends were calculated using rtrim-package (Bogaart *et al.* 2018), which is a specially developed program for analysing ecological data with missing values, specifically time-series of counts using Poisson regression (Pannekoek & van Strien 2005). Rtrim-package was used in R (R Core Team 2013). The multiplicative overall slope (trend) represents the mean growth or decline over a period of time and was determined over the whole time period for which the model was fitted. Plots of the overall slope were created, its 95% confidence band, the total population per time and their 95% confidence intervals. Based on values and confidence intervals (slope ± se), trends were classified into one of the following categories: strong increase/decrease, moderate increase/ decrease, and uncertain. Long-term trends were calculated over the entire period since the early breeding records (1980–2019 for Lake Ptuj and continental Slovenia, 1981–2019 for Ormož Area), and short term trends over the period since the creation of first artificial nest site aimed at target species (2005–2019 for Lake Ptuj and 1997–2019 for Ormož Area).

2.4. Conservation measures

In the overview of conservation measures implemented at sites included in the study, three general types of measures were differentiated according to their specific goal: (1) measures to create/increase the total surface of breeding habitat – the construction of new breeding structures, such as artificial islands and nesting rafts, (2) measures to maintain and enhance breeding habitat through recurring management activities, and (3) measures aimed to increase chick/nest survival and improve breeding success.

3. Results

3.1. Population dynamics

Continental populations of Laridae species breed in Slovenia only on the westernmost fringes of the Pannonian plain, specifically on lowland floodplains of the main rivers of the Danube Basin: Drava, Sava and Mura. After 1979, all nesting locations reported concern artificial structures on heavily altered or entirely man-made water bodies (Table 1, Appendix 1).

Altogether, breeding of Common Tern and Black-headed Gull was recorded at 11 and 10 sites, respectively (Table 2, Figure 1). However, regular breeding of both species over longer periods occurred only at three sites along the Drava River. Lake Ptuj is the single site with mixed-species colony residing in all years of the study period, while at Ormož (two sites) it was established during the early 1990s in the Slovenian territory but moved completely to the Croatian side by the second half of the 2010s (Table 2). At all other sites, suitable nesting habitat became available or provided by management in just a few years, or created only recently. Until 1983, the entire national population of Common Tern bred in the continental part of the country. In that year, the species started breeding at Sečovlje Salina on the Slovenian coast (Škornik 1983), and in 2007 another colony was formed at Škocjanski zatok Nature Reserve as a result of habitat restoration (Table 2). The percentage of national population breeding in continental Slovenia was usually well above 50% throughout the 1980s and 1990s (52–136 pairs), while in the last 16 years (77–258 pairs) it ranged between 40.8% (2015) and 69.0% (2005). Breeding of Black-headed Gull remains largely limited to continental Slovenia with only three breeding records of single pairs from Sečovlje Salina (Table 2). Since 2006, the Mediterranean Gull has been a regular breeder at Lake Ptuj, the only such site in Slovenia.

For most of the study period, the number of breeding Common Terns at Lake Ptuj did not exceed 100 pairs (range 32–91 pairs), and the population was presumably fairly stable from the second half of 1980s to the second half of the 1990s. Probable population low point in the late 1990s and early 2000s is obscured by a lack of data. It was only sometime after the construction of gravel islands in 2014, when the number of pairs increased substantially, reaching a maximum of 218 pairs in 2018 (Table 3). The multiplicative long-term trend of Common Tern at Lake Ptuj was estimated as a moderate increase (1.013 ± 0.002, $P<0.01$) and short-term as a strong increase (1.088 ± 0.008, $P<0.01$). The Black-headed Gull population more than doubled already in the first year after construction of the New Island, and further increased several-fold during the last decade, notably so after the expansion of the colony to gravel islands (Table 4). The latter also triggered a strong increase of the Mediterranean Gull population after a long period of stagnation at very low numbers (Table 5). The multiplicative long-term (1.080 ± 0.001, $P<0.01$) and short-term trend (1.114 ± 0.004, $P<0.01$) of Black-headed Gull at Lake Ptuj is strong increase. Mediterranean Gull trend in the 2006–2019 period was estimated as a strong increase (1.258 ± 0.055, $P<0.05$), too.

In the Ormož Area, the populations of Common Tern and Black-headed Gull reached the highest point during the early 2000s after the largest of the three nesting rafts was constructed at Ormož Basins. However, following the low water level in 2004 that completely prevented breeding and rapid drying of basins due to the cessation of sugar production during the late 2000s, the numbers of both species declined as they gradually moved to the nearby Lake Ormož. While a significant Common Tern population still breeds there, the Black-headed Gull recently became an irregular breeder in low numbers (Table 3 & 4). The multiplicative long-term trend of the Common Tern in the Ormož Area was estimated as a moderate increase (1.096 ± 0.046, $P<0.05$) and short-term as uncertain. For the Black-headed Gull, long-term trend was estimated as uncertain, and short-term trend as a moderate decrease (0.868 ± 0.046, $P<0.05$).

Overall, continental populations of both species in the last few years have been substantially higher compared to the most of the study period, and their long-term trends were estimated as a moderate increase (1.025 ± 0.002, $P<0.01$) for Common Tern and a strong increase (1.077 ± 0.001, $P<0.01$) for Black-headed Gull (Figure 2).

3.2. Conservation measures and their effects

Major threats to the Laridae colonies in our study area are similar as described from other colonies under management (Morris *et al.* 1992, Quinn *et al.* 1996, Cook-Haley & Millenbah 2002): encroachment of nesting habitat by vegetation, terns outcompeted for nest sites by breeding gulls, predation by mammalian and avian predators, erosion of nesting habitat and disturbance by people. Numerous conservation measures were implemented to address these threats.

Measures to create/increase the total surface of breeding habitat

Initially, three artificial nesting rafts were set in place in 1997, 1998 and 2001 in the wastewater basins of the Ormož Sugar Factory (now Ormož Basins Nature Reserve) with the aim to provide long-lasting and predictable Common Tern breeding habitat in the area (Denac 2002b, Božič & Denac 2017). Rafts were constructed and maintained by DOPPS. The size of the rafts was 12, 14 and 96 m^2, respectively. The first raft was functional until 2000, the second until 2002 and the third until 2010. Afterwards, they were all removed and dismantled (Table 1). The Common Tern and Black-headed Gull colonies existed for 12 and nine years on the rafts (1997–2009, except 2004), respectively (Tables 3, 4). The average number of Common Tern breeding pairs on the rafts was 36, and 14 of Black-headed Gull. However, in certain years, such as 2003, predation pressure was high on the rafts and despite the placement of chick shelters, 86% of Common Tern and 64% of Black-headed Gull chicks were predated by Goshawk *Accipiter gentilis* (Denac 2006). Another nesting raft installed at Vrbina gravel pit in 1999 lasted until 2002, when destroyed by anglers (Klenovšek 2003). Over this period, Common Tern bred there in three years (5 pairs on average). The construction of a small nesting platform (1 m^2) at Lake Pernica resulted in Common Tern breeding in 2013 (3 pairs) and 2015 (1 pair).

The first artificial island as a measure for Common Tern conservation was built in autumn 2004 at Lake Ptuj. We named it "New Island" (Table 1). Common Tern and Black-headed Gull started to breed here in 2005. The former bred on New Island between 2005 and 2015 (33 pairs on average), whereas the latter bred in the 2005–2019 period (390 pairs on average) (Tables 3, 4). Mediterranean Gull started to breed on New Island in 2006 (Denac & Božič 2009). Until 2016, only 1–3 pairs bred regularly, but the number increased to 27 pairs in 2019 (Table 5).

The second and the third artificial island were proposed by DOPPS in the "Ecological rehabilitation of Lake Ptuj" study (Božič & Denac 2012) and then constructed in autumn 2014 (Mišič *et al.* 2015). The islands, named "Gravel Island 1" and "Gravel Island 2" (Table 1) were designed to suit the nesting requirements of Common Tern in particular. Common Tern and Black-headed Gull started to breed on Gravel Island 1 in 2015, although the latter in significant numbers only in 2017. The average number of breeding pairs was 73 and 175, respectively. Black-headed Gull started to breed on Gravel Island 2 in 2017 (significantly in 2018) and Common Tern in 2018. The average number of Common Tern breeding pairs was 114, and 96 of Black-headed Gull (Tables 3, 4).

Table 1: Locations with breeding colonial Laridae species (1–3), recorded in continental Slovenia in the 1980–2019 period. Given herewith are the site name at which the location is situated, water body type and its total surface area (ha), nest site definition or location name (unofficial) and its surface area (m^2), year(s) or time period in which it existed together with eventual reason for disappearance, general/technical description, and an outline of vegetation development with indication of suitability for breeding of terns and colonial gull species in a specified period.

Tabela 1: Lokacije z ugotovljenim gnezdenjem kolonijskih vrst (1–3) iz družine Laridae v celinskem delu Slovenije v obdobju 1980–2019. Podani so ime območja, kjer leži lokacija, tip vodnega telesa in njegova celotna površina(ha), opredelitev gnezdišča ali ime lokacije (neuradno) in njegova površina (m^2), leto(-a) ali časovno obdobje, v katerem je obstajala, skupaj z morebitnim razlogom za izgin vrst, splošen/tehničen opis ter oris razvoja vegetacije z navedbo primernosti za gnezdenje čiger in kolonijskih vrst galebov v določenem obdobju.

Site / Območje	Type / Tip	Location (name), nest site / Lokacija (ime), gnezdišče	Surface area / Površina (m^2)	Availability / Razpoložljivost	Distance (m) from shore / Oddaljenost (m) od obale (min)
Lake Ptuj / Ptujsko jezero	Reservoir (Drava River) / akumulacijsko jezero (reka Drava); 450 ha	Small Island / Mali otok	210	1978-	190
		New Island / Novi otok	940	2005-	150
		Gravel Island 1 / Prodnati otok 1	1120	2015-	160
		Gravel Island 2 / Prodnati otok 2	1020	2015-	180
		Transmission line platform (left) / Daljnovodna ploščad levo	30 / 40	1978-	200
		Transmission line platform (right) / Daljnovodna ploščad desno	30 / 40	1978-	210

Description / Opis	Vegetation / Vegetacija
Created accidentally during the flooding of the reservoir basin. The basis is gravel mixed with sand, the central part round plateau c. 150 m^2, c. 1.5 m above average lake level.	Over the years, a layer of soil has formed on the plateau, resulting in the lush growth of herbaceous vegetation, especially *Fallopia japonica* and *Sambucus ebulus*. Until the early 2000s, up to a few meters high willows were growing along the edge of the plateau. Since early 2010s, the island has been unsuitable for breeding of terns and colonial gull species in most years.
The frame constructed of wooden piles interwoven with willows branches filled with silt from the lake bottom. The island is subject to considerable erosion, undermining deeply into the muddy interior.	Entire surface has been overgrowing intensively with various herbs since the first growing season; vegetation composition has changed slightly over the years; in most years *Urtica* sp. and *Phragmites australis* predominate. Along the eastern edge, c. 200 m^2 of reedbed developed in recent years. Due to encroaching of vegetation unsuitable for breeding of Common Tern since 2009.
Constructed of a continuous array of wooden piles along the perimeter, filled with silt from the lake bottom, above which a 50 cm thick, flatten layer of medium-grained gravel is deposited. The pilots are raised along the interior edge to form a c. 1 m high fence, while along the outer edge there is a c. 50 cm high chicken wire fence.	The island is gradually becoming overgrown with *Polygonum* sp. and other herbs in the direction from the outer edge towards the interior.
Constructed of a continuous array of wooden piles along the perimeter, filled with silt from the lake bottom, above which a 50 cm thick, flatten layer of medium-grained gravel is deposited. The pilots are raised along the interior edge to form a c. 1 m high fence. Along the outer edge, a silt-covered gently sloping ramp (length of 30 m) descends from line of the lowered piles, which is completely submerged at higher water levels. Behing a ramp a c. 1 m high, slightly raised plastic fence is installed.	The island is gradually becoming overgrown with *Polygonum* sp. and other herbs in the direction from the outer edge towards the interior.
As of 2015, square-shaped concrete platform with c. 1 m high metal fence around the perimeter to which the steel lattice tower of the transmission line is mounted; the platform is located c. 2 m above average lake level. Until 2014, the platform was round in shape.	None
As of 2015, square-shaped concrete platform with c. 1 m high metal fence around the perimeter to which the steel lattice tower of the transmission line is mounted; the platform is located c. 2 m above average lake level. Until 2014, the platform was round in shape.	None

Continuation of Table 1 / Nadaljevanje tabele 1

Site / Območje	Type / Tip	Location (name), nest site / Lokacija (ime), gnezdišče	Surface area / Površina (m^2)	Availability / Razpoložljivost	Distance (m) from shore / Oddaljenost (m) od obale (min)
Lake Ptuj / Ptujsko jezero	Reservoir (Drava River) / akumulacijsko jezero (reka Drava); 450 ha	Sewer shaft platform (left) / Ploščad kanalizacijskega jaška levo	15	1978-	200
		Debris / naplavine	-	-	30
Ormož basins / Ormoške lagune	Wastewater basins of the Ormož Sugar Factory / Bazeni za odpadne vode Tovarne sladkorja Ormož; 35 ha	Basin 3 / Bazen 3	65500	1980-	-
		Basin 4 / Bazen 4	64550	1980-	-
		Basin 5 / Bazen 5	64300	1980-	-
		Dyke / Nasip	1700	1980-	0
		Nesting raft 1 / Gnezdilni splav 1	12	1997–2000; removed from the basin after the breeding season of the latter year.	70
		Nesting raft 2 / Gnezdilni splav 2	14	1998–2002; removed from the basin after the breeding season of the latter year.	70
		Nesting raft 3 / Gnezdilni splav 3	96	2001–2013; removed from the basin after the breeding season of the latter year (ceased to function as suitable nest site in 2011).	50
Lake Ormož / Ormoško jezero	Reservoir (Drava River) / akumulacijsko jezero (reka Drava); 275 ha	Small artificial structures / Manjše umetne strukture (HR)	60	2006–2014; all structures were removed from the lake prior to the 2015 season.	150
		Large hunting hide / Velika lovska preža (SI)	20	2006–2014; removed from the lake prior to the 2015 season.	450

Description / Opis	Vegetation / Vegetacija
Concrete platform with a metal grate at the top of the sewer shaft (vent), surrounded by c. 1 m high metal fence along the perimeter.	None
Stranded trees, stranded large round hay bale (once).	None
Various structures in the TSO wastewater basin: (1) dry mudflats formed by sedimented industrial effluents at the shallow flooded bottom of the basin; (2) tussocks of tall sedges; (3) islets of floating branches, dry plant parts and similar material; (4) predominantly shingle surfaces exposed by decreasing water levels.	Mudflats and shingle surfaces sparsely overgrown with low herbaceous vegetation.
Islets of floating branches, dry plant parts and similar material in the TSO wastewater basin.	None
Not recorded.	-
Shingle surface of the embankment top between two TSO wastewater basins, c. 3 m wide, occasionally used as a road.	Sparsely overgrown with low herbaceous vegetation.
Anchored flat wooden platform 2 × 6 m with a 7 cm high edges and c. 1 m wide board sloping from raft to the water, mounted on eight (2 rows) floating metal barrels in the basin 4; covered with a thin layer of coarse-grained shingle.	None
Anchored flat wooden platform 2 × 7 m with 7 cm (1998–1999) and 20 cm (2000–2002) high edges, respectively and c. 1 m wide board sloping from raft to the water, mounted on ten (2 rows) floating metal barrels in the basin 4; covered with a thin layer of coarse-grained shingle.	None
Three anchored, firmly interconnected, flat 4 × 8 m wooden platforms with a 35 cm high chicken wire fence around the perimeter, mounted on floating polystyrene blocks in the basin 4; covered with a thin layer of coarse-grained shingle.	The raft became gradually sparsely overgrown with low herbaceous vegetation.
4–5 different small structures on the lake: 2 wooden fishing platforms on poles, c. 1 m above the average water level, and 2–3 hunting hides with a wooden frame low above the water level, masked by dry corn stalks or reed.	None
Similar construction as above but larger.	None

Continuation of Table 1 / Nadaljevanje tabele 1

Site / Območje	Type / Tip	Location (name), nest site / Lokacija (ime), gnezdišče	Surface area / Površina (m^2)	Availability / Razpoložljivost	Distance (m) from shore / Oddaljenost (m) od obale (min)
Lake Ormož / Ormoško jezero	Reservoir (Drava River) / akumulacijsko jezero (reka Drava); 275 ha	Fishing hut / Ribiška hišica (HR)	30	2010–2012; removed from the lake prior to the 2015 season.	430
		Fishing raft / Ribiški splav (HR)	20	2010–2012, 2014; removed from the lake prior to the 2015 breeding season.	450
		Double Island / Dvojni otok (HR)	1000	2012–2014; transformed into the basis of the Island, created in the latter year.	270
		Island / otok (HR)	310	2015-	270
		Debris / naplavine (SI/HR)	-	-	150
Hoče gravel pit / gramoznica Hoče	Gravel pit (active) / gramoznica (aktivna); 21 ha	Peninsula / polotok	150	1989?–1991; transformed in the following years.	0
Hotinja vas fishpond / ribnik Hotinja vas	Fishpond / ribnik; 4.1 ha	Island / otok	60	Until 1984; disappeared after construction of a culvert, resulting in a permanent water level increase.	60
Pragersko clay pit / glinokop Pragersko	Clay pit / glinokop; 2.2 ha	Debris / naplavine	-	-	50
Medvedce reservoir / zadrževalnik Medvedce	Reservoir (Devina stram) / akumulacija (potok Devina); 155 ha (water surface / vodna površina c. 100 ha)	Old tree stumps / Stari drevesni štori	-	1994-	100

Description / Opis	Vegetation / Vegetacija
Wooden fishing platform on poles, c. 1 m above the average lake level, atop of which a simple wooden hut with a flat roof is constructed at half the surface.	None
Anchored flat wooden platform, mounted on three arrays of connected floating metal barrels.	None
Low, gravel-silt mudflat, created accidentally during the machine removal of silt from the lake bottom, exposed at lower water levels.	None
Constructed on a basis of silt and rough stones covered with coarse-grained shingle, formed into a slightly undulating plateau of surface c. 200 m^2, c. 1.5 m above average lake level.	The island is gradually becoming overgrown with herbaceous vegetation and individual woody plants (poplars, willows), especially around the perimeter and lower outer edge.
Stranded trees	None
C. 50 m long end of the longer peninsula, which is the remnant of a former road for removal of gravel, partially flooded with water.	Sparsely overgrown with low herbaceous vegetation.
Elevated gravel surface, c. 1 m above the water during the period of lower water level.	None
Stranded tree	None
Dry stumps protruding low from the water in the flooded part of the reservoir.	None

Continuation of Table 1 / Nadaljevanje tabele 1

Site / Območje	Type / Tip	Location (name), nest site / Lokacija (ime), gnezdišče	Surface area / Površina (m^2)	Availability / Razpoložljivost	Distance (m) from shore / Oddaljenost (m) od obale (min)
Tržec gravel pit / gramoznica Tržec	Gravel pit / gramoznica; 17 ha	Island / otok	20	Occasionally until 1998; disappeared after permanent water level increase for angling purpose.	50
Lake Pernica / Perniško jezero	Reservoir (Pesnica River) / akumulacijsko jezero (reka Pesnica); 103 ha	Island / otok	1000	2003; accidental	10
		Nesting platform / Gnezdilna platforma	1	2013–2017; until collapsed.	130
		Old tree stumps / Stari drevesni štori	-	-	10
		Old tree stumps and reedbed / Stari drevesni štori in trstišče	-	-	150
Gajševci Lake / Gajševsko jezero	Reservoir (Ščavnica River); 67 ha	Island / otok	30	min. 1996-	30
Vrbina gravel pit / gramoznica Vrbina	Gravel pit / gramoznica; 18 ha	Nesting raft / gnezdilni splav	10	1999–2002; destroyed by anglers before the 2003 breeding season.	80
		Island / otok	400	2008–2013	50
Stari Grad gravel pit / gramoznica Stari Grad	Gravel pit (part) / gramoznica (del); 9 ha	Heap of gravel / nasutje proda	1350	2018-	15
Brežiško jezero / Lake Brežice	Reservoir (Sava River) / akumulacijsko jezero (reka Sava); 317 ha	Island / otok	1130	2018-	120

Description / Opis	Vegetation / Vegetacija
Elevated gravel surface, exposed during the period of lower water level.	None
Dry mudflat at the mouth of Pesnica River, exposed at exceptionally low water level in the lake.	Sparsely overgrown with c. 10 cm high herbaceous vegetation. Entire river mouth area significantly expanded and became largely overgrown with willow forest and reedbeds during the 2010s.
Wooden pallet on poles, coated and fenced (height c. 20 cm) around the perimeter with a fine-mesh raschel bag material, covered with a thin layer of gravel and three roof tiles intended as chick shelter.	None
Dry stumps protruding low from the water along the NE shore.	None
Dry stumps protruding low from the water within the reedbed in the marshland area at the mouth of Pesnica River.	None
Mudflat formed by sediment deposition at the mouth of Ščavnica River into the lake.	Partly overgrown by pioneer vegetation at first; since then the entire surface has been overgrowing intensively with woody vegetation to the stage of a willow forest (unsuitable for breeding of Common Tern since c. mid-2000s).
Anchored flat wooden platform 2 × 5 m with c. 20 cm high edges, mounted on eight (2 rows) interconnected floating metal barrels; covered with a thin layer of coarse-grained shingle.	None
Elevated gravel surface, created accidentally during the gravel excavation works in the active part of the gravel pit.	None
A few meters high heap of shingle material surrounded by water.	None
Constructed on a basis of rough stones covered with coarse-grained shingle, formed into a flat plateau of surface c. 780 m^2, on which the individual stone blocks are evenly spaced.	The island is gradually becoming moderately overgrown with woody plants (poplars, willows) and sparse herbaceous vegetation.

Table 2: Number of Common Tern *Sterna hirundo* (left number) and Black-headed Gull *Larus ridibundus* (right number) breeding pairs at all known sites in Slovenia in the 1980–2019 period; x denotes confirmed breeding, but without number recorded.

Tabela 2: Število gnezdečih parov navadne čigre *Sterna hirundo* (leva številka) in rečnega galeba *Larus ridibundus* (desna številka) na vseh znanih območjih v Sloveniji v obdobju 1980–2019; x označuje potrjeno gnezdenje brez zabeleženega števila.

Year / Leto	1	2	3	4	5	6	7	8
1980	x / x							
1981	x / x	27 / 17						
1982	x / x	10 / 10						
1983	x / x				5 / 10			
1984	89 / 112				9 / 0			
1985	x / x							
1986	52 / 85							
1987	57 / 90							
1988	60 / 99							
1989	58 / 100							
1990	69 / 95			24 / 38				
1991	75 / x	1 / 16		59 / 61				1 / 1
1992	50 / 100	10 / 26						4 / 2
1993	45 / 92	22 / 25						26 / 0
1994	42 / 105	15 / 35						
1995	x / x					1 / 0		
1996	x / x							
1997	41 / 150	12 / 6						
1998	x / x	38 / 35						20 / 0
1999	x / x	44 / 55						
2000	x / x	65 / 28						
2001	x / x	64 / 108						
2002	x / x	80 / 140						
2003	32 / x	110 / 112						
2004	91 / 112							
2005	59 / 238	50 / 11						
2006	48 / 355	31 / 21						
2007	47 / 265	49 / 21	3 / 0					
2008	35 / 155	59 / 26	0 / 2					
2009	45 / 435	53 / 7	10 / 19					
2010	56 / 444	35 / 0	37 / 18				0 / 4	
2011	61 / 408	14 / 0	40 / 18				0 / 3	

Year / Leto	9	10	11	12	13	14	15	Total / Skupaj
1980								- / -
1981								- / -
1982								- / -
1983						9 / 0		- / -
1984						15 / 0		113 / -
1985						12 / 0		- / -
1986						18 / 0		70 / 85
1987						15 / 0		72 / 90
1988						19 / 0		79 / 99
1989						20 / 0		78 / 100
1990						22 / 0		115 / 133
1991						41 / 0		177 / -
1992						43 / 0		107 / 128
1993	0 / 5					48 / 0		141 / 122
1994						50 / 0		107 / 140
1995						60 / 0		- / -
1996						53 / 0		- / -
1997						50 / 0		103 / 156
1998						48 / 0		- / -
1999			12 / 0			44 / 0		- / -
2000		15 / 0	1 / 0			51 / 0		- / -
2001		5 / 0				48 / 0		- / -
2002		12 / 0	1 / 0			41 / 0		- / -
2003	2 / 0					62 / 0		206 / -
2004						53 / 0		144 / 112
2005						49 / 0		158 / 249
2006						49 / 0		128 / 376
2007						72 / 0	3 / 0	174 / 286
2008						46 / 0	7 / 0	147 / 183
2009						52 / 0	13 / 0	173 / 461
2010			1 / 0			47 / 1	19 / 0	195 / 467
2011						57 / 0	26 / 0	198 / 429

Continuation of Table 2 / Nadaljevanje tabele 2

Year / Leto	1	2	3	4	5	6	7	8
2012	41 / 521		36 / 10				0 / 2	
2013	78 / 657		9 / 4					
2014	72 / 595		30 / 0					
2015	59 / 526		48 / 18					
2016	85 / 877		82 / 7					
2017	118 / 853		58 / 0					
2018	218 / 988							
2019	117 / 965		30 / 2					

Site names and data sources / Imena območij in viri podatkov:
1 Lake Ptuj / Ptujsko jezero (Janžekovič & Štumberger 1984, Geister 1995)
2 Ormož Basins / Ormoške lagune (Geister 1995)
3 Lake Ormož (border area SI/HR) / Ormoško jezero (mejno območje SI/HR)
4 Hoče gravel pit / gramoznica Hoče (Vogrin 1991a, 1991b)
5 Hotinja vas fishpond / ribnik Hotinja vas (M. Vogrin *pers. comm.*)
6 Pragersko clay pit / glinokop Pragersko (M. Vogrin *pers. comm.*)
7 Medvedce reservoir / zadrževalnik Medvedce (D. Bordjan *pers. comm*)
8 Tržec gravel pit / gramoznica Tržec (Geister 1995, Denac 2003a)
9 Lake Pernica / Perniško jezero (Denac 2002a, Denac 2003b, A. Tomažič *pers. comm.*, M. Gamser *pers. comm.*)
10 Gajševci Lake / Gajševsko jezero (Šalamun 2001, Ž. Šalamun *pers. comm.*)
11 Vrbina gravel pit / gramoznica Vrbina (Denac *et al.* 2010, D. Klenovšek *pers. comm.*)
12 Stari Grad gravel pit / gramoznica Stari Grad (D. Klenovšek *pers. comm.*, *own data*)
13 Brežiško jezero / Lake Brežice (*own data*)
14 Sečovlje Salina / Sečoveljske soline (Škornik 2012, 2019b, I. Škornik *pers. comm.*)
15 Škocjanski zatok (B. Mozetič *pers. comm.*)

Remark / Opomba: Shaded area denotes the sites and time period during which field records were systematically collected by the authors. / Osenčen del označuje območja in časovno obdobje, v katerem sta terenske podatke sistematično zbirala avtorja.

Year / Leto	9	10	11	12	13	14	15	Total / Skupaj
2012						62 / 0	28 / 0	167 / 533
2013	3 / 0					54 / 0	56 / 0	200 / 661
2014						55 / 1	56 / 0	213 / 596
2015	1 / 10					53 / 0	102 / 0	262 / 554
2016	0 / 14					32 / 0	105 / 0	304 / 884
2017						57 / 0	140 / 0	373 / 853
2018				0 / 1	40 / 20	64 / 0	120 / 0	442 / 1010
2019					44 / 0	72 / 0	120 / 0	383 / 967

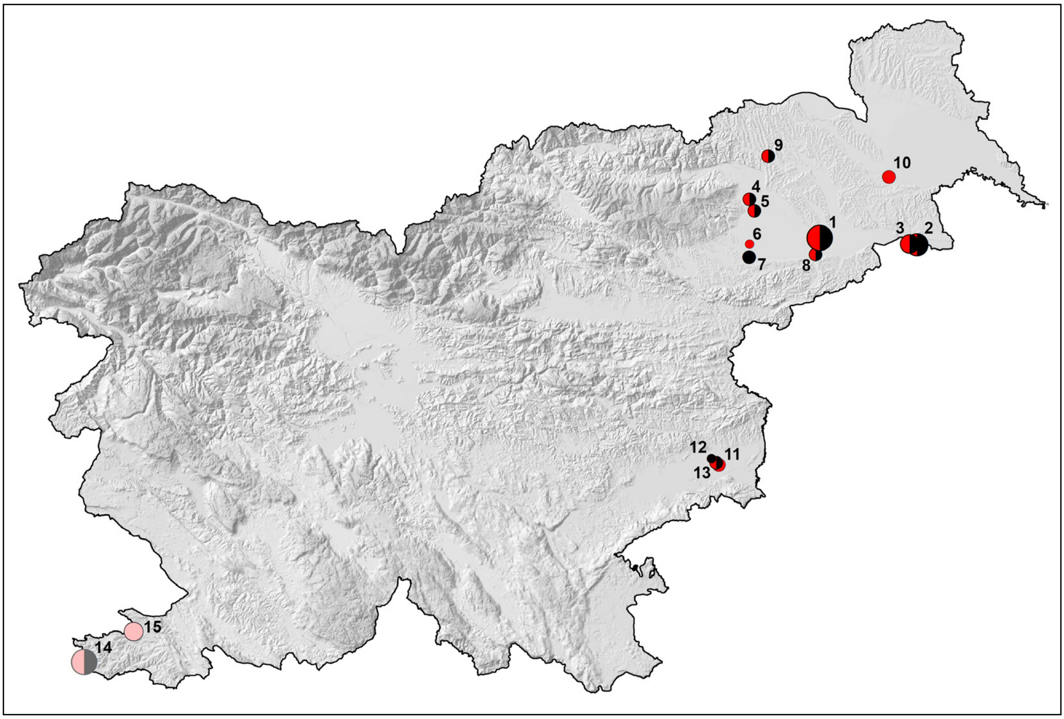

Figure 1: Sites with breeding Common Tern *Sterna hirundo* (red colour) and Black-headed Gull *Larus ridibundus* (black colour), recorded in Slovenia in in the 1980–2019 period and numbered according to Table 2. Dot size corresponds to the total number of years occupied (five size classes: 1, 2–5, 12–13, 20 and 37–40 years).

Slika 1: Območja z ugotovljenim gnezdenjem navadne čigre *Sterna hirundo* (rdeča barva) in rečnega galeba *Larus ridibundus* (črna barva) v Sloveniji v obdobju 1980–2019, oštevilčena glede na tabelo 2. Velikost pike ustreza skupnemu številu let, ko je bilo območje zasedeno (pet velikostnih razredov: 1, 2–5, 12–13, 20 in 37–40 let).

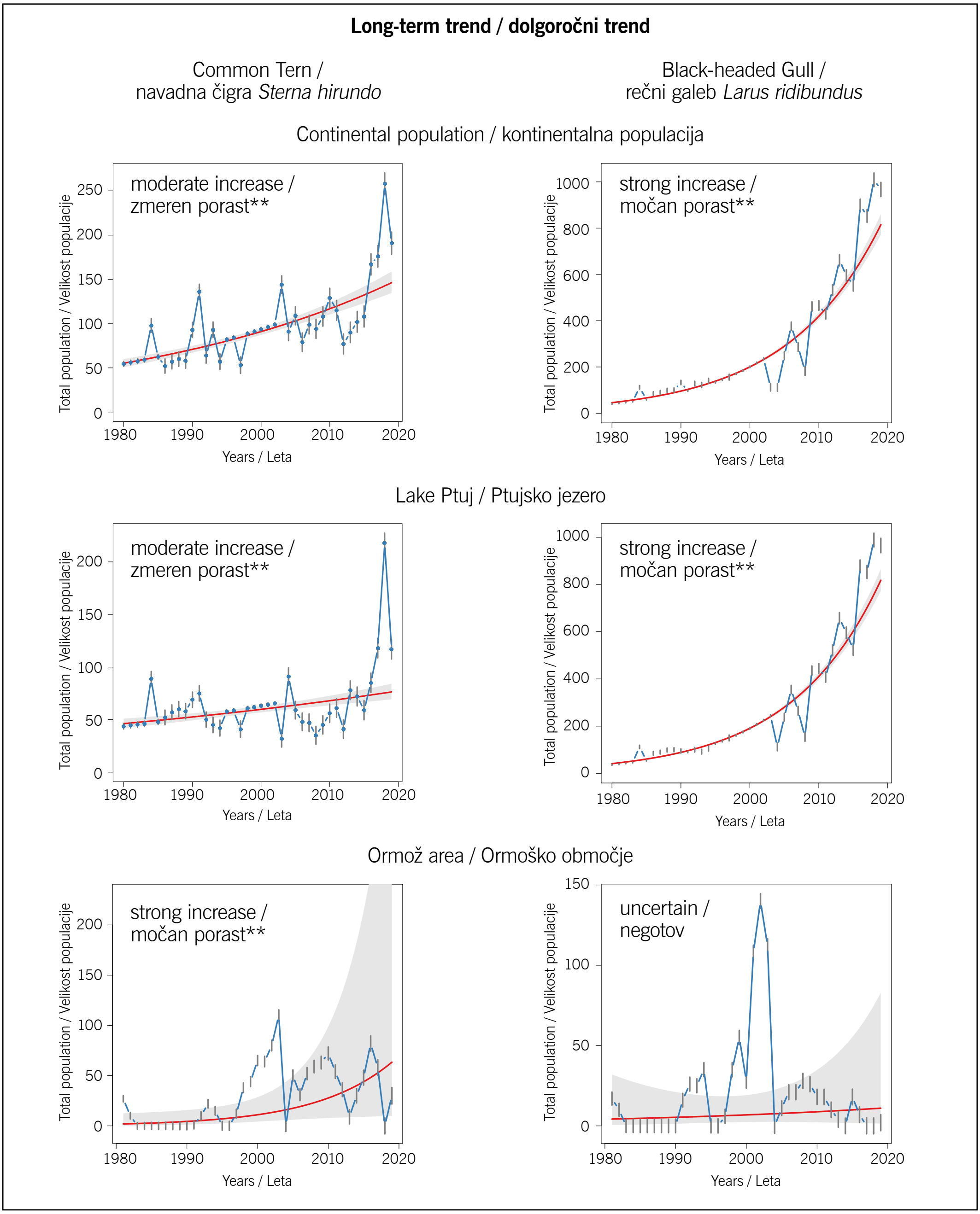

Figure 2: Multiplicative overall slope (long-term and short-term trend), its 95% confidence band, the total population (y axis) per time (x axis) and their 95% confidence intervals for Common Tern *Sterna hirundo* and Black-headed Gull *Larus ridibundus* populations (** $P<0.01$, * $P<0.05$).

Slika 2: Multiplikativni celotni naklon (dolgoročni in kratkoročni trend), njegov 95 % pas zaupanja, velikost populacije (y os) v času (x os) in njen 95% interval zaupanja za populacije navadne čigre *Sterna hirundo* in rečnega galeba *Larus ridibundus* (** $P<0.01$, * $P<0.05$).

Continuation of Figure 2 / Nadaljevanje Slike 2

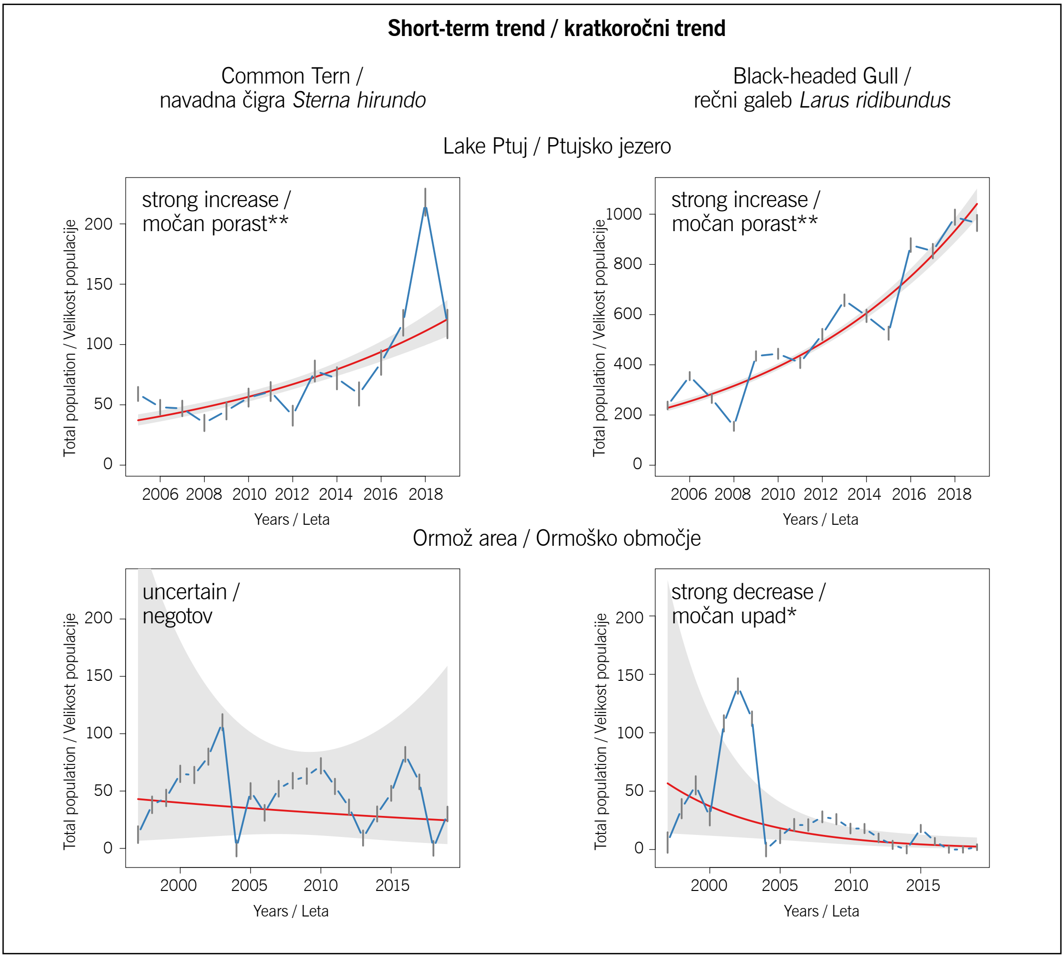

Table 3: Number of Common Tern *Sterna hirundo* breeding pairs on different locations at three sites along the Slovenian/border part of the Drava River in the 1980–2019 period; x denotes confirmed breeding, but without number recorded. Breeding of presumably the same pairs (replacement clutches) at different location in the same year is denoted in bold.

Tabela 3: Število gnezdečih parov navadne čigre *Sterna hirundo* na različnih lokacijah na treh območjih vzdolž slovenskega/mejnega dela reke Drave v obdobju 1980–2019; x označuje potrjeno gnezdenje brez zabeleženega števila. Gnezdenje domnevno istih parov (nadomestna legla) na različnih lokacijah v istem letu je označeno krepko.

Site, location / Območje, lokacija	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Lake Ptuj / Ptujsko jezero																
Small Island / Mali otok	x [1,2]	x [1,2]	x [1,2]	x [1,2]	89 [1]	x [2]	52 [2]	57 [2]	60 [2]	58 [2]	64 [2]	75 [2]	50 [2]	45 [2]	42 [2]	x
New Island / Novi otok	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gravel Island 1 / Prodnati otok 1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gravel Island 2 / Prodnati otok 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Transmission line platform (left) / Daljnovodna ploščad levo											2 [3]					
Transmission line platform (right) / Daljnovodna ploščad desno											3 [3]					
Sewer shaft platform (left) / Ploščad kanalizacijskega jaška levo																
Lake Ormož / Ormoško jezero																
Small artificial structures / Manjše umetne strukture (HR)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Large hunting hide / Velika lovska preža (SI)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fishing hut / Ribiška hišica (HR)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fishing raft / Ribiški splav (HR)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Double Island / Dvojni otok (HR)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Island / otok (HR)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Debris / naplavine (SI/HR)																
Ormož Basins / Ormoške lagune																
Nesting raft 1 / Gnezdilni splav 1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nesting raft 2 / Gnezdilni splav 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nesting raft 3 / Gnezdilni splav 3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Basin 3 / Bazen 3		27 [2]	10 [2]									1	10 [4]	22 [4]	1 [4]	
Basin 4 / Bazen 4																
Dyke / Nasip															14 [4]	

1 Janžekovič & Štumberger (1984)
2 Geister (1995)
3 Bračko (1999)
4 Denac (2002b)
5 Denac (2006)
6 Denac (2004)
7 Rubinić *et al.* (2005)
8 Mihelič *et al.* (2006)
9 Rubinić *et al.* (2007)
10 Rubinić *et al.* (2008)
11 Rubinić *et al.* (2009)
12 Denac *et al.* (2010)
13 Denac *et al.* (2011)
14 Denac & Božič (2013)
15 Božič (2018)
16 Božič (2019)

1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
x	1	?	?	?	?	?				3[8]	6[9]	15[10]	**25**[11]				24[15]						
-	-	-	-	-	-	-	-	-	37[7]	45[8]	21[9]	3[10]	**19**[11]	41[12]	34[13]	25[14]	42[15]	59[15]	**32**				
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	56[15]	85[15]	118[15]	70[15]	38[16]
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-				148[15]	79[16]
							17	85[6]	20[7]		15[9]	12[10]	38[11]	1[12]	2[13]	2[14]	12[15]	11[15]					
	40	?	7	10	?	?	15	4[6]	2[7]		5[9]	5[10]	7[11]	14[12]	25[13]	14[14]		1[15]					
								2[6]										1[15]	3[15]				
-	-	-	-	-	-	-	-	-	-		3		10[11]	28[12]	22[13]		8[15]	10[15]	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-						6[13]		-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	9[12]	12[13]		-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-			**14**[14]	-	20[15]	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	36[14]			-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	48[15]	82[15]	58[15]		30[16]
																	1[15]						
-	5[4]	13[4]	19[4]	30[4]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	20[4]	22[4]	35[4]	14[4]	5[4]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	45[4]	59[4]	110[5]		50[7]	31[8]	45[9]	58[10]	53[11]					-	-	-	-	-	-
	7[4]		1[4]			16[4]					4[9]	1[10]		35[12]	14[13]								
		5[4]	2[4]		5[4]																		

Remark / Opomba: Unnumbered records are unpublished data of the authors. / Neoznačeni zapisi so neobjavljeni podatki avtorjev.

- Location did not exist in a given year. / Lokacija v tem letu ni obstajala.

? No data / Brez podatka

SI The location is situated on the Slovenian side of the lake. / Lokacija leži na slovenski strani jezera.

HR The location is situated on the Croatian side of the lake. / Lokacija leži na hrvaški strani jezera.

Table 4: Number of Black-headed Gull *Larus ridibundus* breeding pairs on different locations at three sites along the Slovenian/border part of the Drava River in the 1980–2019 period; x denotes confirmed breeding but without number recorded.

Tabela 4: Število gnezdečih parov rečnega galeba *Larus ridibundus* na različnih lokacijah na treh območjih vzdolž slovenskega/mejnega dela reke Drave v obdobju 1980–2019; x označuje potrjeno gnezdenje brez zabeleženega števila.

Site, location / Območje, lokacija	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Lake Ptuj / Ptujsko jezero																
Small Island / Mali otok	x[1,2]	x[1,2]	x[1,2]	x[1,2]	112[1]	x[2]	85[2]	90[2]	99[2]	100[2]	95[2]	x[2]	100[2]	92[2]	105[2]	x
New Island / Novi otok	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gravel Island 1 / Prodnati otok 1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gravel Island 2 / Prodnati otok 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Transmission line platform (left) / Daljnovodna ploščad levo																
Transmission line platform (right) / Daljnovodna ploščad desno																
Debris / naplavine																
Lake Ormož / Ormoško jezero																
Small artificial structures / Manjše umetne strukture (HR)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Large hunting hide / Velika lovska preža (SI)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fishing hut / Ribiška hišica (HR)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fishing raft / Ribiški splav (HR)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Island / otok (HR)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Debris / naplavine (SI/HR)																
Ormož Basins / Ormoške lagune																
Nesting raft 1 / Gnezdilni splav 1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nesting raft 2 / Gnezdilni splav 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nesting raft 3 / Gnezdilni splav 3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Basin 3 / Bazen 3		17[2]	10[2]									16	26[3]	25[3]	32[3]	
Basin 4 / Bazen 4																
Basin 5 / Bazen 5																
Dyke / Nasip															3[3]	

1 Janžekovič & Štumberger (1984)
2 Geister (1995)
3 Denac (2002b)
4 Denac (2006)

1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
x	150	?	x	?	?	?	?	70	150	80	75	32					21	2			31	13	
-	-	-	-	-	-	-	-	-	14	160	100	70	353	340	339	471	575	514	516	843	631	495	435
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	33	162	292	389
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			6	164	117
								7	24	40	35	26	36	53	31	33	25	25	5		22	24	24
								35	50	75	55	27	46	51	38	17	36	54	3				
																			1	1	1		
-	-	-	-	-	-	-	-	-	-				11	8	7	3	3		-	-	-	-	-
-	-	-	-	-	-	-	-	-	-				8	6	5	7	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4		-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-				-		-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	18	7			2
												2			2		1						
-			3[3]	3[3]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-		3[3]	3[3]	4[3]	3[3]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	100[3]	110[3]	112[4]		11	21	18	26	5										
	6[3]					27[3]					3												
		35[3]	49[3]	22[3]	3[3]								2										
					1[3]																		

Remark / Opomba: Unnumbered records are unpublished data of the authors. / Neoznačeni zapisi so neobjavljeni podatki avtorjev.

- \- Location did not exist in a given year. / Lokacija v tem letu ni obstajala.
- ? No data / Brez podatka
- SI The location is situated on the Slovenian side of the lake. / Lokacija leži na slovenski strani jezera.
- HR The location is situated on the Croatian side of the lake. / Lokacija leži na hrvaški strani jezera.

Table 5: Number of Mediterranean Gull *Larus melanocephalus* pairs on different locations at Lake Ptuj since the first confirmed breeding in 2006

Tabela 5: Število parov črnoglavega galeba *Larus melanocephalus* na različnih lokacijah Ptujskega jezera od prvega potrjenega gnezdenja leta 2006

Site, location / Območje, lokacija	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Small Island / Mali otok								1	1					
New Island / Novi otok	1[1]	2[1]	1[1]	2[1]	2	2	1	2	1	1	2	1		27
Gravel Island 1 / Prodnati otok 1	-	-	-	-	-	-	-	-	-		13	11	6	1
Gravel Island 2 / Prodnati otok 2	-	-	-	-	-	-	-	-	-				20	
Transmission line platform (right) / Daljnovodna ploščad desno						1								
Total / Skupaj	1	2	1	2	2	3	1	3	2	1	15	12	26	28

[1] Denac & Božič (2009)

Remark / Opomba: Unnumbered records are unpublished data of the authors. / Neoznačeni zapisi so neobjavljeni podatki avtorjev.
- Location did not exist in a given year. / Lokacija v tem letu ni obstajala.

Mediterranean Gulls bred on both Gravel Islands as well, on the first one in all years since 2016 (majority of population there in 2016–2017) and on the second one only in 2018, but with a significant number. Average number of breeding pairs on both Gravel Islands was 10 (Table 5).

In Oct–Nov 2014, an island designed as a nest site for Common Tern was constructed in the Croatian part of Lake Ormož (Table 1), based on experience from Lake Ptuj and under supervision of the Association Biom (BirdLife in Croatia). In the years 2015–2019, 55 pairs of Common Tern and 9 pairs of Black-headed Gull bred on average on the island (Tables 3, 4), but there was no breeding in 2018, presumably due to predation by the Eurasian Otter *Lutra lutra* in previous years.

As part of mitigation measures, required to minimise negative impacts of HPP Brežice (Official Gazette of RS 2012, 2013), an island aimed as nest site for Common Tern was constructed in 2017, during the building of a reservoir. In two seasons available, 40 and 44 Common Tern pairs bred there, while Black-headed Gull bred only in 2018 (20 pairs).

Measures to maintain and enhance the breeding habitat – management techniques

Different types of recurring management techniques were applied at nest sites (Table 6). Measures 1–9 were aimed at vegetation control and prevention of habitat loss. Without regular implementation of these measures, the habitat would become unsuitable for breeding of target species in a year or two. Therefore, they form a crucial part of conservation efforts for the species. Since 2005, nesting locations subjected to conservation measures were mostly visited twice per year for management purposes, before the start of breeding season in spring (March) and afterwards in autumn (September, October). Management is mostly carried out by DOPPS staff and volunteers. Between 2003 and 2019, a total of 2,230 man-hours were invested in the management of nesting locations.

(1) Mowing with sickle bar mower

Since 2010, sickle bar mower has been used to cut the vegetation on New Island every autumn (Appendix 2a). Mowing with sickle bar mower replaced the brush cutters, as it proved far more efficient and less strenuous on the workers. Blade height was set 10 cm above the ground and was fixed. This has been the only island where the amount of vegetation required this measure to be performed. To date, annual mowing of New Island has been the basic management technique to make the sparsely to moderately vegetated ground suitable for breeding of large proportion of the Black-headed Gull colony.

(2) Mowing with brush cutters

Brush cutters were used between 2005 and 2010 to control vegetation on New Island (Appendix 2a). Vegetation was cut either in autumn or/and in spring. Two or three brush cutters with iron blades were used simultaneously. Brush cutters were also used on Gravel Island 2 to remove vegetation from the silty outer edge. This method was used to provide sparsely vegetated ground as a breeding habitat for Common Tern and Black-headed Gull and it proved to be sufficient only for the first three consecutive years from the construction of the island (2005–2007). After 2008 a more efficient combination of covering ground with foil was necessary to retain suitable ground for the breeding Common Terns (see measure 3). Brush cutters were replaced by more effective sickle bar mower in 2010.

(3) Covering the ground by plastic foil

The number of Black-headed Gull breeding pairs on New Island increased many-fold during 2005–2008, occupying almost the entire available space before the arrival of Common Terns. Furthermore, upon return of terns to the breeding grounds, vegetation was already c. 20 cm high, causing rapid deterioration of their breeding habitat during the nest site selection period in the years 2006–2008. Consequently, after the first breeding of Common Tern on New Island (2005), its population increased next year, but decreased to 21 and 3 pairs in the following two years (Table 3). In order to tackle this issue, a piece of black plastic foil (sized c. 3 × 7 m), intended to delay vegetation growth, was placed on the ground in early March (Appendix 2b), prior to Black-headed Gulls settling on the island, for the first time in 2009. Stones, acting as weights, were put on the foil edges to prevent them from being lifted by wind, and a net of strings (see measure 9) with mesh size c. 1 × 1 m was installed c. 0.5 m above the foil. The latter was then removed during a short visit to the island in late April of the same year, aimed at counting the Black-headed Gull nests. This procedure was repeated annually on New Island for seven consecutive years between 2009 and 2015. The foil was always placed on the same place. This measure provided c. 20 m^2 of sparsely vegetated ground on New Island, enabling Common Tern to breed (Appendix 2c). By applying this measure, its population increased to 19 pairs in 2009 (all breeding on the surface where foil was placed; Denac *et al.* 2010) and to an average of 39 pairs in the following years until 2015. Afterwards, the measure was abandoned as Common Tern started breeding on Gravel island 1 (Table 3). Already in the following year, the species did not breed on New Island at all, highlighting the importance of the measure in maintaining the breeding population at Lake Ptuj during the first half of the 2010s.

(4) Removal of woody vegetation

The measure was carried out at Lake Ptuj (New Island and Small Island), islands at Lake Ormož and Lake Brežice, and nesting location at Gajševci Lake. On New Island, willows were planted along the edge during its construction, with the purpose to stabilize the perimeter and reduce the erosion effect. Tree roots have effectively protected and stabilized the island. However, tree crowns had to be cut every year with chainsaw to keep the island open and free of visual barriers for colonial breeders. This type of management has been done every autumn since the construction of New Island (2005). A similar measure was conducted on Small Island until the late 1990s, when willows were finally eliminated from the island by regular cutting. Starting in 2016, encroaching woody vegetation is being removed manually from the island at Lake Ormož on annual basis, before the start of the

Common Tern breeding season by members of the Association Biom. In March 2019, the first removal of pioneer woody vegetation (young willows and poplars) was carried out on the island at Lake Brežice by using gardening tools like hoe, hand saw, pick and garden shears (Appendix 2d). At Gajševci Lake, cutting of willows encroaching upon the mudflat was carried out by chainsaw in some years of the 2000s, before the management of the location was abandoned due to heavy predation on Common Tern nests and chicks (Ž. Šalamun *pers. comm.*).

(5) Removal of herbaceous vegetation

Gravel Islands 1 and 2, as well as Small Island are covered by gravel, which renders mowing of their surfaces practically impossible. Instead, manual pulling/rooting out (by hands or using digging tools) of herbaceous vegetation has been performed to provide for bare shingle surfaces each year before the start of the breeding season. This technique was also a basic management method for the concrete transmission line platforms, as the substrate was formed from the old Black-headed Gull nests and excrements of Cormorants *Phalacrocorax carbo* roosting on lattice towers, resulting in vegetation growth. As a rule, the vegetation was removed from the platforms together with the entire guano layer to keep them suitable for breeding of Common Tern (Appendix 2e). Throughout the 1980s and first half of the 1990s, Small Island was the most important (and in most years the only) breeding location for Common Tern, making such management crucial for the preservation of the colony. Common Tern colonized Small Island again in the years 2006–2009, when the number of Black-headed Gulls breeding there almost halved, albeit in smaller numbers (Table 3). Predation by Yellow-legged Gull that started breeding on Small Island in 2009 probably forced terns to abandon this breeding site. Finally, the excessive encroachment by invasive plants over the entire island surface prevented further breeding of Common Tern in the last few years of the study period, despite all efforts invested. Recently, the manual pulling management on Gravel Islands 1 and 2 (Appendix 2f) supports the largest Common Tern colony and significant proportion of Black-headed Gull population in the continental part of Slovenia. At a smaller scale, the method is also used to remove herbaceous vegetation from the island at Lake Ormož (carried out by the Association Biom).

(6) Covering the ground with wood chips

Wood chips were experimentally used on New Island to prevent rapid overgrowing and to secure suitable breeding place for Common Terns. An area of 24 m^2 (4 × 6 m^2) was covered with a 10 cm layer of wood chips with geotextile laid beneath in spring 2010 (Appendix 2b). The plot was adjacent to the one covered with plastic foil (see measure 3). In the same year, 17 pairs of Common Tern bred on wood chips (plus additional 24 on the surface where foil was placed), suggesting it was an appropriate breeding substrate for the species (Appendix 2g). The substrate was, however, short-lived. In the next year, it was mostly overgrown and in 2012 it more or less disappeared, with vegetation on the plot hardly differing from its surrounding. In spring 2019, a plot of c. 100 m^2 on New Island was covered with pine bark wood chips and geotextile laid beneath (Appendix 2h). The plot remained largely unvegetated throughout the breeding season with only a few single Reed *Phragmites australis* stems penetrating through. Almost the entire colony of Mediterranean Gull (27 pairs) moved there, together with a few Black-headed Gull pairs (Appendix 2i). Following these promising results, the area covered with pine chips was enlarged to c. 250 m^2 in autumn of the same year (preparation for breeding season 2020).

(7) Applying salt

Sea salt was experimentally used on Small and New Islands as a potential natural herbicide. On two small plots of the same size, 20 and 50 kg of salt was evenly dispersed and later compared to a control plot with no application. No effect was registered and the technique was not further implemented.

(8) Preventing the nesting habitat erosion
Since the erosion has reduced the surface area of Small Island significantly, it was restored and consolidated by wooden piles hammered along the plateau perimeter in the late 1990s. Gravel Islands 1 and 2 turned out to be highly prone to erosion as well. Along the interior edge exposed to the river current, the material became eroded and large holes appeared in some places (Appendix 2j), causing intrusion of water and partial flooding of the islands at high water levels of the reservoir. In addition, steep erosion holes were dangerous to chicks, for once they fell into they were unable to climb up again, which caused additional mortality. In autumn 2018, holes were covered by cloth and filled with gravel, eliminating the threat.

(9) Raising of nesting location by bringing silt and shingle material
Due to the high risk of flooding, the mudflat at Gajševci Lake on which Common Tern started to breed in 2000, was elevated by manually adding silty material from the surroundings to the central part of the nesting location, consolidated with wooden piles before the start of the ensuing season. Furthermore, 12 m^3 of shingle was brought to stabilise the location next year. With a combination of different measures, the breeding population of Common Tern there was maintained for further two years, but management efforts were abandoned shortly afterwards (Ž. Šalamun *pers. comm.*).

Measures aimed to increase chick/nest survival and to improve breeding success

Conservation measures summarized in this section include a diverse set of efforts, ranging from management practices conceived to prevent predation and to control occupancy of breeding locations by gulls, to measures aimed at reducing direct negative impacts of recreational activities, including general public awareness of conservation issues.

(10) Fencing
Protective fencing was set up on both transmission line platforms. The right one was fenced in 1999 and the left one in 2003. The fences prevented chicks from falling into the water and drowning (once a chick fell into the water, it was impossible for it to return due to the height of the platform) (Appendix 2k). They were 30 cm high and made of chicken wire with mesh size 1 × 1 cm. Both old platforms were removed and new ones constructed on exactly the same locations in 2014. They were fenced in the same manner in spring 2016. Gravel Island 1 was fenced with 50 cm high chicken wire along the vertical outer edge, where chicks could fall into the water and would no longer be able to return to the island (Appendix 2l). The outer edge of Gravel Island 2 is gently sloping. It was fenced to prevent access (and potential trampling of nests) to numerous Mute Swans *Cygnus olor* to the gravel surface of the island (Appendix 2m), as observed on regular basis before the measure was implemented. Also, their droppings significantly contribute to undesired vegetation growth by fertilizing the ground. The lower edge of the fence is 15 cm above the ground to enable Common Tern and gull chicks and ducklings to pass underneath. Both Gravel Islands were fenced in autumn 2015. In spring 2019, some sections along the interior edge of gravel islands were fenced with 30 cm high plastic mesh, protected with plastic foil along the lower part, to prevent chicks falling through the gaps in the array of wooden poles (Appendix 2n). The gaps appeared due to the pressure of the islands' building material on the perimeter and have probably been one of the major causes of mortality since at least 2017.

(11) Placing of plastic strings to prevent breeding of gulls
On New Island, a grid of plastic strings (max. spacing 1 m) supported by wooden poles, was placed c. 1 m above the ground over the plots covered with foil and wood chips (see measures 3 and 6) to prevent Black-headed Gull pairs from occupying the plots (Appendix 2b). They were placed in early spring between 2009 and 2015, prior to gulls settling at the breeding location. Strings were removed together with the foil in late April, when most Black-headed Gulls are usually already in mid- or late phase of incubation period, but Common Terns

just start breeding. Thus, the measure enabled terns to occupy the available plot free of gulls in the middle of the dense Black-headed Gull colony. Upon the removal of foil, the ground was sparsely vegetated and therefore suitable for Common Tern (Appendix 2c). Black-headed Gulls did not attempt to breed at the plots with strings. In 2011 and 2014, a grid of plastic strings was placed in the same manner over the entire plateau surface of Small Island, aimed to prevent breeding of Yellow-legged Gull (predator of Common Tern chicks). It proved unsuccessful as it bred among strings in both years (Appendix 2o). This method was adopted from the USA model, used to reduce aerial predation and gull occupancy in the Common Tern colony (Audubon Vermont 2009, 09:33).

(12) Placing chick shelters

Chick shelters (Burness & Morriss 1991) were placed for the first time on bare concrete transmission line platforms where Common Tern started to breed (Appendix 2p). They were placed in 1999 on the right platform and 2003 on the left one. After the platforms were replaced, new shelters were set in place in 2016. Before the start of the 2003 breeding season, Nesting raft 3 in Ormož Basins was also equipped with shelters (18), designed as an "open-ended tent", constructed from rectangular pieces of wooden plank (30 × 15 cm) nailed together (Appendix 2q). Nevertheless, severe predation by the Goshawk that managed to pull the chicks from underneath the shelters was observed in the same year (Denac 2006). Afterwards, the original unsuccessful shelters were replaced with a longer version (1 m) and breeding success probably improved somewhat in 2005 (cf. Rubinić *et al.* 2005). These remained functional for the entire life period of the rafts. About 10 ridge roof tiles aimed to serve as chick shelters were present on the plateau of Small Island in the 2010–2014 period, but remained largely

Table 6: Conservation measures carried out on locations with breeding colonial Laridae species at sites along the Slovenian/border part of the Drava River in the 2005–2019 period. Seasons when specific measures were implemented in individual years are given (S – spring, before the start of the breeding season; A – autumn, after the breeding season). Numbers correspond to the numbering in the section 3.2.

Tabela 6: Varstveni ukrepi, izpolnjeni na lokacijah z gnezdečimi kolonijskimi vrstami iz družine Laridae na treh območjih vzdolž slovenskega/mejnega dela reke Drave v letih 2005–2019. Naveden je letni čas, ko so bili izpeljani določeni ukrepi v posameznih letih (S – spomladi, pred začetkom gnezditvene sezone; A – jeseni, po gnezditveni sezoni). Številke ustrezajo oštevilčenju v podpoglavju 3.2.

	2005		2006		2007		2008		2009		2010	
Site, location / Območje, Lokacija	S	A	S	A	S	A	S	A	S	A	S	A
Lake Ptuj / Ptujsko jezero												
Small Island / Mali otok	4,5,7		4,5	5		5	7	5		4,5	12	4,5
New Island / Novi otok		2	2	2,4		2,4	2,7	2,4	2,3,4,11	2,4	3,6,11	1,2,4
Gravel Island 1 / Prodnati otok 1												
Gravel Island 2 / Prodnati otok 2												
Transmission line platform (left) / Daljnovodna ploščad levo			5	5		5		5		5		5,10
Transmission line platform (right) / Daljnovodna ploščad desno		5	5	5		5		5		5		5
Lake Ormož / Ormoško jezero												
Island / Otok (HR)												
Artificial structures / Umetne strukture (SI/HR)												

unused as the island was seldom occupied by breeding pairs during that period. In spring 2017, 48 chick shelters made of two plywood planks were placed on Gravel Island 1. Apparently, they were mostly used by Black-headed Gulls, as the majority of chick shelters had at least one gull nest next to it.

(13) Installation of electric fence

Heavy predation by Eurasian Otter resulted in extremely low breeding success of Common Terns nesting on the island at Lake Ormož in the years 2015–2017. To solve this problem, a portable battery-powered electric fence was installed around the plateau of the Island (action carried out by the Association Biom) (Appendix 2r). However, the system did not prevent the Otter entering the fenced area in 2019 during the late phase of incubation period. All nests were predated again, and most of the terns left the site soon thereafter, without attempting to replace the clutch.

(14) Reducing human disturbance

DOPPS - BirdLife Slovenia was actively involved in the preparation of Decree on navigation regime at Drava River and Lake Ptuj, adopted by the Municipality of Ptuj (Official Gazette of RS 2006). The Decree regulates navigation on the lake, including enforcement of temporal and spatial restrictions with 100 m "no-disturbance" zone around nesting locations. However, the Municipality did not provide for sufficient field control, and violations of the Decree provisions still occur fairly often, occasionally causing disturbance to the breeding colony. An observation tower with detailed information on Common Tern and other birds was opened for public in 2016, with telescope for observing the colony installed in the tower.

(15) Removal of ecological traps

In the 2009–2014 period, Common Terns and Black-headed Gulls bred on several illegally built fishing and hunting platforms and

2011		2012		2013		2014		2015		2016		2017		2018		2019	
S	A	S	A	S	A	S	A	S	A	S	A	S	A	S	A	S	A
11	4,5		4	5	4	11	5		5		5		5		5		5
3,4,11	1,4	3,4,11	1,4	3,11	1,4	3,11	1,2,4	3,11	1,4		1,4		1,4		1,4	6	1,4,6
									5,10		5	12	5		5,8	10,12	5
									5,10		2,5		5		5,8	10	5
	5		5		5					10,12							
	5		5		5					10,12							
										4,5		4,5	4,5	4,5,13	4,5	4,5	
							15										

similar structures at Lake Ormož (on average 14 and 6 pairs, respectively). The platforms functioned as ecological traps due to the fact that all nests were destroyed by visiting people in most of the years. In autumn 2014, all platforms were removed, thereby eliminating the ecological traps. Consequently, both species bred at Lake Ormož only on the artificial island in the following years.

4. Discussion

Common Tern occupies a wide range of nest sites and its breeding habitat was even described as "wherever they find a place, provided that conspecific breeders have settled there before", but the requirement for open ground, safe from terrestrial predators and flooding, with nests usually laid on bare substrate or very low vegetation, render its continental distribution rather local and closely connected with provision of artificial sites. Common Terns quickly exploit such sites, especially in areas where natural sites are scarce (Becker & Ludwigs 2004). Furthermore, the survival of Slovenian population was based on the availability of man-made water bodies since all known natural nest sites were lost through river regulation at the turn of the 1970s. However, suitable conditions there were mostly only temporary, resulting in short-lived or intermittent breeding. Due to the lack of suitable nest sites, Common Terns often bred at suboptimal locations with very low breeding success due to flooding of nest sites with low elevation (Double Island at Lake Ormož, Denac & Božič 2013), predation (Gajševci Lake, Ž. Šalamun *pers. comm.*), negative intra-specific interactions arising from very high nest densities (transmission line platform at Lake Ptuj, Božič & Denac 2012), or human-related mortality (Hoče gravel pit, Vogrin 1991b; artificial structures at Lake Ormož, Denac *et al.* 2011). Moreover, breeding attempts (copulation, nest building) were recorded on hardly suitable, freshly exposed small surfaces which were then flooded before the start of egg-laying (Vrbina and Stari Grad gravel pit; D. Klenovšek *pers. comm.*), further illustrating quick exploitation of potential nest sites when these are scarce. Similar holds true for Black-headed Gull, except for the fact that it did not occupy completely open locations, devoid of any kind of vegetation or structures, like featureless areas of bare substrate (shingle or mud) on newly created artificial islands, low mudflats and small rafts. As soon as some patches of vegetation appeared or structures like chick shelters were placed, gulls begun to colonize such sites as well (e.g. gravel islands at Lake Ptuj). Black-headed Gulls are known to occupy open, sparsely vegetated sites only after the arrival of Common Terns (Glutz von Blotzheim & Bauer 1999) and, indeed, such settlement pattern was observed on Gravel Islands at Lake Ptuj. Although Common Terns occasionally breed amidst taller vegetation and some shrubs, preferred sites can quickly become unsuitable due to rapid encroachment, caused by natural succession and/or competition with gulls, which settle at more vegetated areas (Glutz von Blotzheim & Bauer 1999, Becker & Ludwigs 2004, Cabot & Nisbet 2013) as was the case with several locations in continental Slovenia, including those constructed intentionally as nest sites for Common Tern.

In continental Slovenia, long-term preservation of regularly breeding significant populations of Common Tern and associated gulls is completely management dependent (Denac *et al.* 2019, Denac & Božič 2019, Božič & Denac 2019). The continental Common Tern population could be considered a metapopulation, consisting of a few subpopulations at different sites. The main purpose of the conservation programme has been therefore to preserve a viable continental Common Tern metapopulation. Taking into account all of its challenges over the years, it is one of the most intensive species conservation programmes of DOPPS-BirdLife Slovenia. In the 1980s and early 1990s, this required relatively moderate resources as only a single breeding location had to be maintained annually at that time. Furthermore, Common Tern started to breed at several other anthropogenic habitats, like gravel pits and wastewater basins of the Ormož Sugar Factory (now Ormož Basins Nature Reserve), or nest sites created accidentally on man-made water bodies. However, all such habitats turned out to be suitable for breeding for only a very short period (a year or two) due to their intermittent character and/or rapid encroachment of vegetation on freshly exposed surface, as documented by several sites where breeding occurred only in few years over the period of several decades.

In addition, for various reasons it was not feasible to implement conservation management at most of these sites. The only sites, where long-term management was possible, were wastewater basins of the Ormož Sugar Factory. There, an agreement with the company's management was achieved and artificial nesting rafts placed in 1997, 1998 and 2001 (Božič & Denac 2017). Thus, new breeding structures intended for Common Tern conservation were created for the first time. This was important, as in the late 1990s the species stopped breeding on Small Island due to the increased competition with Black-headed Gull (Božič & Denac 2012). Most likely, the pairs from Lake Ptuj moved to breed on artificial rafts in the wastewater basins. Strong predation on the rafts in 2003 (Denac 2006), combined with unfavourable water regulation regime in the basins, caused abandonment of the breeding location in the following year. In 2004, Common Terns bred in larger numbers at transmission line platforms, which clearly indicated a lack of suitable breeding habitats along the entire Drava River area. Despite the management efforts, neither the rafts nor the platforms turned out to be a long-term solution in the Common Tern conservation programme. High nest densities thereon resulted in negative intra- and interspecific interactions that negatively affected fecundity (Denac 2002b, 2004, 2006), which is a common consequence under such circumstances (Glasmacher 1987, Budde 1992, Sudmann 1998). Therefore, a new stable and optimal breeding habitat was required in order to preserve the most important Common Tern colony in continental Slovenia. New Island was built at the Lake Ptuj in 2004/2005 and Common Terns immediately started to breed there in 2005. New Island, on the other hand, was constructed without the final placement of gravel layer, and had to be mown annually to remove the high herbaceous vegetation. Specific habitat conditions favouring Black-headed Gull developed soon on New Island and its numbers increased significantly. Upon construction, both gravel islands offered an optimal Common Tern breeding habitat. However, the nesting ecological niche of the Common Tern partly overlaps with that of the Black-headed Gull (Fasola & Canova 1992), so every new nest site of the former is also a potential site for the latter. This is exactly what happened at both Gravel Islands – Black-headed Gull occupied them over time, resulting in increase of their population. Despite the fact that their surface is covered with a thick gravel layer, the encroaching of vegetation has intensified over years, to the point that in 2019 the islands were largely covered with continuous stand of dense herbaceous vegetation already by mid-June (most Common Tern pairs at chick stage). Terns avoid dense vegetation because it obscures visual contact and recognition between chicks and parents, making delivery of fish more difficult. Dense vegetation also prevents chicks from drying after heavy rain or dew (Kress 2000). Evidence exists that low Common Tern fledging success on Gravel Islands in 2019 is at least partly related to the moist conditions in the lush herb layer (*own data*). Consequently, more resources and introduction of new conservation measures will be needed to prepare suitable nest sites on Gravel Islands for the following breeding seasons.

The Common Tern conservation programme was launched and is being implemented by DOPPS-BirdLife Slovenia. In the 1980s and 1990s, management was organized and carried out by volunteers only. During the last two decades it has been organized by DOPPS' staff, but performed with extensive help of volunteers. Management equipment used is owned by DOPPS and volunteers. Common Tern is a qualifying Natura 2000 species for SPA Drava (SI5000011). The "Natura 2000 management programme for the period 2015–2020", adopted by the Government of Slovenia (Government of RS 2015), specifies "management of breeding islands" as a measure to protect the Common Tern at the SPA. DOPPS is listed as the responsible institution and volunteer work as "financial source". The amount of volunteer workload required to accomplish annual conservation measures has been steadily increasing: in the 2004–2008 period, 432 man-hours were needed for conservation management, in the 2009–2014 period a total of 712 man-hours, and in the 2015–2019 period 1086 man-hours were invested. These numbers do not include preparatory and monitoring activities. Altogether, 161 different volunteers have participated in the management since 2003. We conclude that with this dramatically increased workload and rising demands of tasks implemented, the current predominantly volunteer-based model is no longer sustainable in the long term and a more supportive state mechanism is urgently required.

There are many further positive effects of the activities carried out within the frame of Common Tern conservation programme. Following the example of breeding islands at Lake Ptuj in Slovenia, a similar island was built by the Croatian power company "Hrvatska elektroprivreda d.d." in 2014 and Common Tern bred there in 2015 for the first time. Bird species that were new for Slovenia or the Podravje region started to breed on the islands, such as Red-crested Pochard *Netta rufina* and Yellow-legged Gull *Larus michahellis*. Breeding population of Tufted Duck *Aythya fuligula* increased substantially after the construction of islands at Lake Ptuj (*own data*).

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showed much understanding when using access to Ptuj Lake. The Association Biom (BirdLife in Croatia) succeeded in their efforts to remove all illegal structures that acted as ecological traps for Common Tern at Lake Ormož – a problem that has influenced birds for years. Under its umbrella, management of the island at Lake Ormož was also started, and carried on since 2016 by the following members: Sandra Hodić, Tomislav Hudina, Biljana Ječmenica, Ivan Katanović, Monika Korša, Iva Šoštarić, Florbella Torres, Josip Turkalj and Mate Zec.

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5. Povzetek

V članku je obravnavana dolgoročna populacijska dinamika (1980–2019) kolonijskih vrst iz družine Laridae v celinski Sloveniji z opisi njihovih gnezdišč na antropogenih vodnih telesih in naravovarstvenih ukrepov s poudarkom na varstvu navadne čigre *Sterna hirundo* vzdolž slovenskega/mejnega dela reke Drave. Obravnavane vrste tu gnezdijo na zahodnem obrobju Panonske nižine, na nižinskih poplavnih ravnicah velikih rek donavskega povodja. Gnezdenje navadne čigre je bilo potrjeno na 11, rečnega galeba *Larus ridibundus* pa na 10 območjih. Ptujsko jezero je edino območje, na katerem je mešana kolonija obeh vrst gnezdila v celotnem obravnavanem obdobju. Pri Ormožu (na dveh območjih) je kolonija nastala v zgodnjih 90. letih na območju Slovenije, po letu 2010 pa se je povsem preselila na hrvaško stran. Na vseh drugih območjih so bila ustrezna gnezdišča, nastala naključno ali z upravljanjem, na voljo le nekaj let oz. narejena šele nedavno. V 80. in 90. letih je v kontinentalni Sloveniji gnezdilo več kot 50 % nacionalne populacije navadne čigre (52–136 parov), v zadnjih 16 letih pa 40,8–69,0 % (77–258 parov). Rečni galeb gnezdi skoraj izključno v celinski Sloveniji. Celinski populaciji obeh vrst sta v zadnjih letih bistveno večji, kot sta bili večino obdobja raziskave; dolgoročni trend za navadno čigro je bil ocenjen kot zmeren porast, za rečnega galeba pa kot močan porast. Črnoglavi galeb *L. melanocephalus* je reden gnezdilec Ptujskega jezera od leta 2006 (do 28 parov), kar je edino gnezdišče te vrste v državi. Podrobno so predstavljene tri splošne skupine naravovarstvenih ukrepov, izpeljane na različnih lokacijah: (1) ukrepi za povečanje obsega gnezditvenega habitata – izdelava novih gnezdilnih struktur, kot so umetni otoki in gnezditveni splavi, (2) ukrepi za ohranjanje in izboljšanje gnezditvenega habitata z vsakoletnim upravljanjem, in (3) ukrepi za izboljšanje preživetja gnezd in mladičev ter povečanje gnezditvenega uspeha.

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DODATEK / APPENDIX 1

Locations with breeding colonial Laridae species in continental Slovenia: Small Island at Lake Ptuj in May 1997 (a), on 21 Apr 2010 (b) and on 7 May 2018 (c); New Island at Lake Ptuj in the first breeding season after construction (Common Tern *Sterna hirundo* nests visible), 4 Jun 2005 (d), on 20 Apr 2012 (e) and on 7 May 2018 (f); Gravel Island 1 at Lake Ptuj in the first breeding season after construction, 30 Jun 2015 (g), on 11 May 2019 (h) and on 22 Jun 2019 (i); Gravel Island 2 at Lake Ptuj on 11 May 2019 (j) and on 24 Jul 2019 (k); left transmission line platform at Lake Ptuj, 23 May 2006 (l) and platform detail, 24 Apr 2019 (m); right transmission line platform at Lake Ptuj, 15 Jun 2012 (n); left sewer shaft platform at Lake Ptuj, 13 Jun 2015 (o); nest of a Black-headed Gull *Larus ridibundus* on a stranded large round hay bale at Lake Ptuj, 21 Apr 2017 (p); shingle surface exposed by decreasing water levels at Ormož Basins (Basin 3), 1 Jun 2011 (q); dry mudflats formed by sedimented industrial effluents at Ormož Basins (Basin 3), 24 May 2007 (r); Common Tern breeding on floating branches at Ormož Basins (Basin 4), (s); Nesting raft 1 (t), Nesting raft 2 (u) and Nesting raft 3 (v) at Ormož Basins; nesting locations at Lake Ormož in the first half of the 2010s – small hunting hide, 24 May 2014 (w), wooden fishing platform, 8 Feb 2009 (x), large hunting hide, 14 Feb 2009 (y), fishing hut, 25 Jan 2011 (z), fishing raft, 26 May 2014 (aa) and Double Island, 15 Jun 2012 (ab); Island at Lake Ormož in the first breeding season after construction, 28 May 2015 (ac) and on 7 Jun 2019 (ad); peninsula at Hoče gravel pit in both years with breeding recorded – Jul 1990 (ae) and Mar 1991 (af); Black-headed Gull nest site at Medvedce reservoir (ag); nesting platform at Lake Pernica just after construction, 20 Apr 2013 (ah); Island at Gajševci Lake (ai); nesting raft at Vrbina gravel pit, May 1999 (aj); heap of gravel at Stari Grad gravel pit, 10 May 2018 (ak); Island at Lake Brežice in the first breeding season after construction, 22 May 2018 (al). Photos: T. Basle (c, f, h, j, ad, ah, al), L. Božič (a, b, e, g, i, k–n, p, v–ac), D. Denac (d, s–v, ai), D. Klenovšek (aj, ak), M. Vogrin (o, ae, af), R. Tekavčič (q), D. Tome (r)

Lokacije z ugotovljenim gnezdenjem kolonijskih vrst iz družine Laridae v celinskem delu Slovenije: Mali otok na Ptujskem jezeru maja 1997 (a), 21. 4. 2010 (b) in 7. 5. 2018 (c); Novi otok na Ptujskem jezeru v prvi gnezditveni sezoni po izgradnji (vidna so gnezda navadne čigre *Sterna hirundo*), 4. 6. 2005 (d), 20. 4. 2012 (e) in 7. 5. 2018 (f); Prodnati otok 1 na Ptujskem jezeru v prvi gnezditveni sezoni po izgradnji, 30. 6. 2015 (g), 11. 5. 2019 (h) in 22. 6. 2019 (i); Prodnati otok 2 na Ptujskem jezeru 11. 5. 2019 (j) in 24. 7. 2019 (k); leva daljnovodna ploščad na Ptujskem jezeru, 23. 5. 2006 (l) in detajl ploščadi, 24. 4. 2019 (m); desna daljnovodna ploščad na Ptujskem jezeru, 15. 6. 2012 (n); leva ploščad kanalizacijskega jaška na Ptujskem jezeru, 13. 6. 2015 (o); gnezdo rečnega galeba *Larus ridibundus* na naplavljeni veliki okrogli bali na Ptujskem jezeru, 21. 4. 2017 (p); prodnata površina, izpostavljena zaradi upadajoče vodne gladine v Ormoških lagunah (bazen 3), 1. 6. 2011 (q); suhi poloji, nastali s sedimentacijo industrijskih izpustov v Ormoških lagunah (bazen 3), 24. 5. 2007 (r); navadna čigra, gnezdeča na plavajočih vejah v Ormoških lagunah (bazen 4) (s); Gnezdilni splav 1 (t), Gnezdilni splav 2 (u) in Gnezdilni splav 1 (v) v Ormoških lagunah; gnezditvene lokacije na Ormoškem jezeru v prvi polovici 2010-ih let – majhna lovska preža, 24. 5. 2014 (w), lesena ribiška ploščad, 8. 2. 2009 (x), velika lovska preža, 14. 2. 2009 (y), ribiška hišica, 25. 1. 2011 (z), ribiški splav, 26. 5. 2014 (aa) in Dvojni otok, 15. 6. 2012 (ab); otok na Ormoškem jezeru v prvi gnezditveni sezoni po izgradnji, 28. 5. 2015 (ac) in 7. 6. 2019 (ad); polotok v gramoznici Hoče v obeh letih z ugotovljenim gnezdenjem – julij 1990 (ae) in marec 1991 (af); gnezdišče rečnega galeba na zadrževalniku Medvedce (ag); gnezdilna platforma na Perniškem jezeru takoj po postavitvi, 20. 4. 2013 (ah); otok na Gajševskem jezeru (ai); gnezdilni splav na gramoznici Vrbina, maj 1999 (aj); kup proda v gramoznici Stari Grad, 10. 5. 2018 (ak); otok na Brežiškem jezeru v prvi gnezditveni sezoni po izgradnji, 22. 5. 2018 (al). Foto: T. Basle (c, f, h, j, ad, ah, al), L. Božič (a, b, e, g, i, k–n, p, v–ac), D. Denac (d, s–v, ai), D. Klenovšek (aj, ak), M. Vogrin (o, ae, af), R. Tekavčič (q), D. Tome (r)

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Nadaljevanje dodatka 1 / Continuation of Appendix 1

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Nadaljevanje dodatka 1 / Continuation of Appendix 1

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APPENDIX 2 / DODATEK 2

Conservation measures implemented at different nesting locations of colonial Laridae species in continental Slovenia: (a) mowing with sickle bar mower and brush cutter on New Island, (b) ground covered by plastic foil and wood chips on New Island, intended to delay vegetation growth, and grid of plastic strings supported by wooden poles placed above it to prevent Black-headed Gulls *Larus ridibundus* from occupying this area, (c) sparsely vegetated area on New Island after removal of plastic foil, with breeding Common Terns *Sterna hirundo*, (d) removal of pioneer woody vegetation from the island at Lake Brežice using gardening tools, (e) right transmission line platform after removal of vegetation and guano layer, (f) manual pulling of herbaceous vegetation on Gravel Island 1, (g) the plot with wood chips during the breeding of Common Terns, (h) area of c. 100 m^2 on New Island covered with pine bark wood chips, (i) aerial view of the latter area with colony of Mediterranean Gull *L. melanocephalus*, (j) erosion hole dangerous to chicks along the interior edge of Gravel Island 1, (k) protective chicken wire fence along the perimeter of transmission line platform, preventing chicks from falling into the water (Black-headed Gull chicks on the photo), (l) installation of chicken wire along the vertical outer edge of Gravel Island 1, (m) plastic fence along the outer edge of Gravel Island 2 aimed to prevent access of Mute Swans *Cygnus olor* to the gravel surface of the island, (n) section along the interior edge of the gravel island fenced with plastic mesh, protected with plastic foil on the lower part, to prevent chicks falling through gaps in the array of wooden poles, (o) grid of plastic strings placed over the plateau surface of Small Island, which did not prevent Yellow-legged Gull *L. michahellis* from breeding there (nest visible in the centre), (p) Wooden chick shelter placed on transmission line platform with Common Tern chicks, (q) chick shelters 30 × 15 cm on Nesting raft 3 which did not prevent severe predation of Common Tern and Black-headed Gull chicks by Goshawk *Accipiter gentilis*, (r) a portable, battery-powered electric fence installed around the plateau of the Island at Lake Ormož did not prevent the Eurasian Otter *Lutra lutra* entering the fenced area during the breeding of Common Terns. Photos: T. Basle (i), G. Bernard (d), L. Božič (b, g, m–o), D. Denac (a, e, f, h, j–l, p, q), T. Hudina (r)

Naravovarstveni ukrepi, izpeljani na različnih gnezditvenih lokacijah kolonijskih vrst iz družine Laridae v celinski Sloveniji: (a) košnja s samohodno in nahrbtno kosilnico na Novem otoku, (b) površina prekrita s plastično folijo in lesnimi sekanci, namenjenimi zaviranju rasti vegetacije, ter mreža iz plastičnih vrvic nad njo za preprečevanje naselitve rečnih galebov *Larus ridibundus*, (c) skromno poraščena površina na Novem otoku po odstranitvi plastične folije, z gnezdečimi navadnimi čigrami *Sterna hirundo*, (d) odstranjevanje pionirske lesnate vegetacije z otoka na Brežiškem jezeru z uporabo vrtnarskega orodja, (e) desna daljnovodna ploščad po odstranitvi vegetacije in plasti gvana, (f) ročno puljenje zelnate vegetacije na Prodnatem otoku 1, (g) ploskev z lesnimi sekanci v času gnezdenja navadne čigre, (h) površina na Novem otoku velikosti c. 100 m^2, prekrita s sekanci borovega lubja, (i) pogled iz zraka na slednjo površino s kolonijo črnoglavega galeba *L. melanocephalus*, (j) mladičem nevarna erozijska luknja vzdolž notranjega roba Prodnatega otoka 1, (k) zaščitna žična ograja vzdolž oboda daljnovodne ploščadi za preprečevanje padanja mladičev v vodo (na sliki so mladiči rečnega galeba), (l) nameščanje žične ograje vzdolž navpičnega zunanjega roba Prodnatega otoka 1, (m) plastična ograja vzdolž navpičnega zunanjega roba Prodnatega otoka 2, namenjena preprečevanju dostopa labodov grbcev *Cygnus olor* na prodnato površino otoka, (n) odsek na notranjem robu prodnatega otoka s plastično mrežo, zaščiteno s plastično folijo na spodnjem delu, za preprečevanje padanja mladičev v vodo skozi vrzeli v nizu lesenih pilotov, (o) mreža iz plastičnih vrvic, nameščena čez ravno površino Malega otoka, ki ni preprečila gnezdenja rumenonogega galeba *L. michahellis* (gnezdo vidno na sredini), (p) leseno zatočišče za mladiče na daljnovodnem podstavku z mladiči navadne čigre, (q) zatočišča za mladiče 30 × 15 cm na Gnezdilnem splavu 3, ki niso preprečila velikega plenjenja mladičev navadne čigre in rečnega galeba s strani kragulja *Accipiter gentilis*, (r) prenosna baterijska električna ograja, nameščena okoli ravne površine otoka na Ormoškem jezeru, ni preprečila vstopa vidre v ograjeno območje v času gnezdenja navadne čigre. Foto: T. Basle (i), G. Bernard (d), L. Božič (b, g, m–o), D. Denac (a, e, f, h, j–l, p, q), T. Hudina (r)

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Nadaljevanje dodatka 2 / Continuation of Appendix 2

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Dynamics of Common *Sterna hirundo* and Little Tern *Sternula albifrons* populations along the Sava River in North-western Croatia between 2002 and 2019

Populacijska dinamika navadne čigre S*terna hirundo* in male čigre *Sternula albifrons* ob Savi v severozahodnem delu Hrvaške med letoma 2002 in 2019

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Between 2002 and 2019, monitoring of Common Tern *Sterna hirundo* and Little Tern *Sternula albifrons* along the Sava River near Zagreb, Croatia was conducted. Natura 2000 site "Sava kod Hrušćice" was designated to protect colony at river islands, with estimated population sizes of 100–150 pairs of Common and 20 pairs of the Little Tern. Flooding of the colony caused breeding failure in several years. Common Terns moved to breed on islands in gravel pits with a total population around 150 pairs, while Little Tern did not breed after 2010. In the last few years, terns have not bred at Hrušćica and the only colony inside the Natura 2000 site is situated on a breeding platform at Siromaja gravel pit. Channelling of rivers and hydropower plants are the main threats, changing natural dynamics of water level and causing reduction of gravel sediment in rivers.

Key words: Common Tern *Sterna hirundo*, Little Tern *Sternula albifrons*, Sava River, monitoring, Natura 2000 site, threats
Ključne besede: navadna čigra *Sterna hirundo*, mala čigra *Sternula albifrons*, reka Sava, monitoring, območje Natura 2000, grožnje

1. Introduction

In Croatia, the Common Tern *Sterna hirundo* and Little Tern *Sternula albifrons* inhabit the Adriatic and continental regions. Continental populations of both species are concentrated along the middle stretches of the Sava and Drava Rivers, where gravel substrate and natural river morphological processes allow creation of river islands, their main breeding habitat. The Little Tern is Endangered at the national level, while the Common Tern is Near Threatened (Tutiš *et al.* 2013). The main identified threats are channelling rivers, construction of dams, accumulations and embankments, and water pollution (Tutiš *et al.* 2013).

Along the Sava River, adequate natural breeding habitats are found in a relatively small area, around the city of Zagreb, where the river changes its flow from the fast upper to slow lower flow. The area is designated as the Natura 2000 site „Sava kod Hrušćice". It covers 1,527 ha of riverbed and gravel pits, riparian forests and agricultural land, with breeding population of the Common Tern estimated at 100–150 pairs, and of the Little Tern at 20 pairs (Radović *et al.* 2005, Natura2000 2019). The main threats are river canalisation, water pollution and unregulated recreational activities (Radović *et al.* 2005). The Sava River at Zagreb has the Peripannonian pluvial-nival discharge regime, with maximum values in April and November (Čanjevac 2013). Such water regime, with low water levels between May and August, is favourable for breeding terns. However, the increase of the Sava River water level is not only the result of precipitation and melting of snow, but is also affected by hydropower dams upstream in Slovenia. Operation of hydropower plant is causing rapid and short-term fluctuations in downstream river flow, called hydropeaking. The fluctuations occur several times per day and cause flooding of low-lying islands along the river. Another effect of hydropower plants is a reduction of gravel sediment in the river. Dams interrupt the continuity of sediment transport, causing lowering of riverbed by erosion, coarsening of bed material and loss of gravel (Kondolf 1997). A long-term study showed a decrease in maximum annual concentrations and annual transfer of suspended sediment in the Sava River at Zagreb (Trninić & Bošnjak 2009).

Apart from the river itself, terns also bred at gravel pits around Zagreb: Abesinija (45°46' N, 16°09' E), Siromaja 2 (45°45' N, 16°11' E), Veliko Čiče (45°42' N, 16°05' E), Rakitje (45°47' N, 15°50' E) and Blato (45°46' N, 15°52' E). The first two belong to the Natura 2000 site „Sava kod Hrušćice", while others are situated outside that area. Gravel pits may present safe breeding sites, but adequate habitats are rarely found: some gravel surfaces are dry only during the lowest water level, while others are close to the shore and may become connected with the mainland during the low water level, enabling access to predators. Only some lakes have islands that are high enough above the water to be safe from flooding, but these are often overgrown by vegetation.

This paper aims to give an overview of the dynamics and threats of tern populations along the Sava River in the surroundings of Zagreb.

Figure 1: Breeding sites arround Zagreb (see Introduction for details)

Slika 1: Gnezdišča v okolici Zagreba (podrobni opisi v uvodu)

2. Methods

Monitoring of terns in Croatia started in 2002. In early years, more effort was given to the more threatened Little Tern, so exact data for Common Terns are missing (Hrvatsko ornitološko društvo 2010). Repeated visits were carried out to known and potential colony sites from April to July (or August in years with late clutches). Between three and six visits were conducted annually until 2018. In 2018 and 2019, population size was monitored by weekly visits during the breeding season.

Monitoring was launched by the Institute of Ornithology, Croatian Academy of Sciences and Arts, and continued by the Croatian Ornithological Society until 2012. Monitoring of colonies on the Sava River between 2013 and 2016 was conducted by the Croatian Society for the bird and nature protection (Mikuska *et al.* 2017). From 2015, monitoring at Rakitje was conducted through cooperation of the Public Institution "Green Ring" and the Institute of Ornithology. In 2018 and 2019, it was carried out as part of the Interreg SI-HR project "ČIGRA".

Data from monitoring reports, as well as authors' own data were used. Monthly precipitation data were taken from the Croatian Meteorological and Hydrological Service (CMHS 2019) for meteorological station Zagreb - Grič.

3. Results and Discussion

3.1. Common Tern

The Common Terns were monitored from 2002, but complete data are at hand only for the period after 2009, when 152.9 (± 19.4) pairs on average bred annually in the surroundings of Zagreb (Table 1). In the early 2000s, the stronghold of the Common Tern population on the Sava River bred inside Natura 2000 site Sava kod Hruššćice, on a gravel island on the Sava River and occasionally in Abesinija gravel pit. However, breeding was found to be unsuccessful, due to flooding of the whole colony between 2003 and 2006. In 2004, terns colonised a low gravel island in the southern part of Rakitje gravel pit that existed until 2009. Between 55 and 70 pairs bred there, with the exception of 2006, when only two pairs were recorded. In 2007, breeding on that island was unsuccessful, and next year terns started breeding on a gravel peninsula closer to the northern shore. In 2009, about 70 pairs started breeding at the peninsula, while 65–70 pairs bred on the island, which was again flooded after the start of the breeding season. That autumn, with the help of local gravel producer "Tempo", the peninsula was converted into an island, which became the most important colony for Common Tern to date. However, to retain the habitat on the island suitable for breeding of terns, the Institute of Ornithology and the Public Institution "Green Ring" have been since 2015 regularly removing vegetation from the island during autumn and early spring.

In 2006, small waterbodies were excavated along the channel Sava–Odra, near Blato. Several small gravel islands formed there, providing appropriate nesting conditions for terns. Up to 120 pairs nested there until 2014. However, some islands were overgrown by vegetation, while surfaces of the others are too close to the water and are not suitable for breeding every year.

3.2. Little Tern

The Little Tern colony was situated on a gravel island inside the Natura site "Sava kod Hruššćice" with nests usually constructed very low above the water. After four years of unsuccessful breeding due to flooding (2003–2006), chicks finally successfully fledged in 2007. In the ensuing year, only about half of the pairs attempted breeding which, however, was unsuccessful once more. After that, the colony was abandoned. A final single breeding pair was observed there in 2010, but breeding was again unsuccessful (Figure 2). Individual pairs bred at gravel pits Rakitje in 2006 and Blato in 2008 and 2009, but colonies never formed there. So, in the period between 2002 and 2010, breeding was successful in only three years: 2002 and 2007 at Hruššćica and in 2009 at Blato (one pair). After 2010, no breeding of Little Tern has been recorded in the surroundings of Zagreb, although individual birds were observed, for example in the Common Tern colony at Rakitje on 2 June 2019.

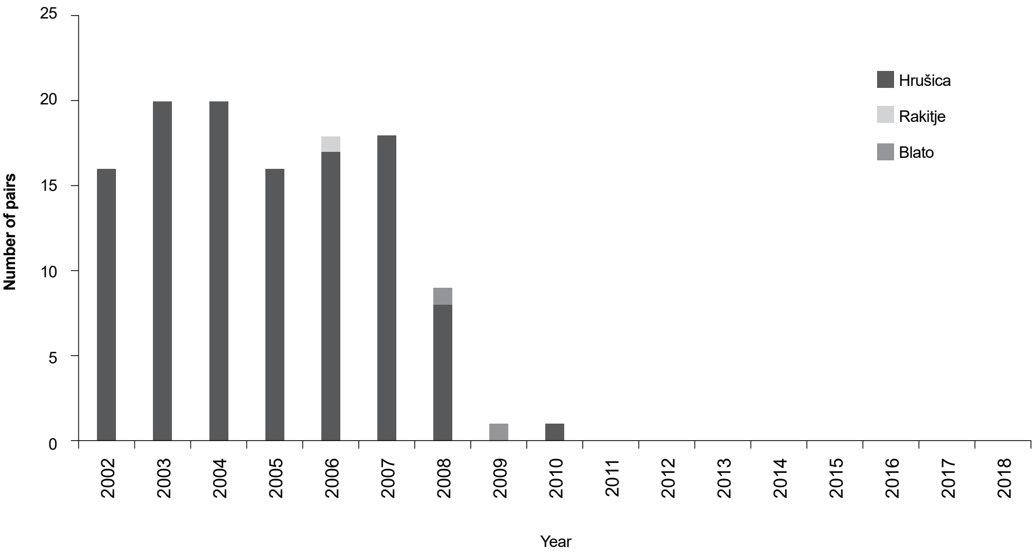

Figure 2: Numbers of Little Tern breeding pairs along the Sava River

Slika 2: Število gnezdečih parov male čigre ob Savi

3.3. Threats to tern colonies

Terns are generally considered to have high breeding philopatry, but site fidelity is often higher in large, stable colonies than in colonies in less stable habitat (González-Solís *et al.* 1999, Palestis 2014). Frequent changes of colony location in the surroundings of Zagreb are the result of habitat instability. Colony size and breeding success vary annually, depending on water level and island vegetation cover. Increase of the water level during the breeding season (recorded for example on 2 July 2005 and 24 May 2006) caused, together with a lack of gravel sediment, repeated flooding of colonies situated on river islands, and was the main driver for displacing the colony to the surrounding gravel pits. In order to enable breeding of terns, regular removing of the vegetation from such islands is needed. Although being a relatively simple and cheap management method, its main weakness is that it must be done every year, preferably both before and after the breeding season.

More intensive monitoring in 2018 and 2019 enabled a more detailed tracking of the effect of water level change on tern breeding phenology. Both seasons had atypical precipitation regimes. In 2018, heavy snowfall in February (precipitation was 102.3 mm) caused extremely high groundwater level, so all islands were flooded until mid-June. That year, terns started breeding on a breeding platform (size 8 × 8 m) installed within the Interreg SI-HR project "ČIGRA" in mid-May 2018 at Siromaja gravel-pit inside the Natura 2000 site, and on a metal gravel excavator at Veliko Čiče gravel pit. Breeding at Rakitje started in mid-June, and the breeding season there finished 1.5 months later than usual with last unfledged chicks observed on 23 August 2018.

In 2019, the weather in winter was very dry and warm. Monthly precipitation values for the first three months of 2019 were between 16.9 and 39.5 mm, while the average values from the 1861–2018 period for the same months were 46.9–55.1 mm. By contrast, the precipitation was very high in May (123.1 mm, compared to an average of 82.0 mm). Therefore, in early May, terns started breeding on numerous small islands at Rakitje and Blato that emerged owing to the low water level, but were later flooded. After almost the entire colony at Blato was flooded in the last

Table 1: The number of breeding pairs of Common Terns near Zagreb. Total numbers are estimated taking into account the timing of nesting, as in some years terns move to another site after failure of their first clutch. + breeding was confirmed, but numbers are not known, * failure of the whole colony, ** breeding mostly unsuccessful, 0 locality was monitored, but no breeding was confirmed, empty cells - no data.

Tabela 1: Število gnezdečih parov navadne čigre pri Zagrebu. Ocena števila upošteva obdobje gnezdenja, saj lahko po propadu gnezda čigre gnezdijo ponovno drugje. + gnezdenje je bilo potrjeno, število neznano, * propad celotne kolonije, ** gnezdenje večinoma neuspešno, 0 kolonija je bila opazovana, a podatkov o gnezdenju ni, prazen prostor – ni podatka.

Year / leto	Sava / Hrušćica	Rakitje	Blato	Abesinija	Siromaja 2	Čiče	TOTAL
2002	50			20–25			70–75
2003							
2004	15*	50		10			75
2005	+*	45–50					>50
2006	+*	2*	65				>67
2007	+	55–60*	50				>110
2008	+	55–60	1				>60
2009	70	135	50				180
2010	30	40	150				180
2011		30	100				130
2012	0	50	80	0			120
2013		30–40	100–110				130–150
2014	45	0	100–120				145–165
2015	70	90–95					160–165
2016	50	100	0				150
2017	0	100–110	50				150–160
2018	0	106	0	0	30	51**	140
2019	0	134	>70*	0	39	0	170

days of May, terns moved to Rakitje, where they produced replacement clutches. The breeding season there was prolonged, and finished about one month later than usual, with last unfledged chicks observed on 5 August 2019.

In 2013, the Natura 2000 site "Sava kod Hrušćice" was designated to protect tern colonies, but with a lack of appropriate nature conservation measures colonies were devastated due to frequent flooding. The population of the Common Tern around Zagreb remained stable, but population moved from their natural habitat on river islands to artificial islands at gravel pits in the surroundings of the Sava River. Moreover, the only colony inside the Natura site is on a breeding platform raised under the Interreg SI-HR project "ČIGRA" in 2018 to protect this species. Therefore, an effort was made to change the boundaries of the Natura site to include the most important nesting location today, the gravel pit Rakitje. The Little Tern unfortunately didn't accept the gravel pit islands as their nesting sites and no breeding attempt has been recorded since 2010. Therefore, the only inland breeding locality of that species nowadays is on the Drava River between Legrad and Repaš (Mohl 2001, Tutiš *et al.* 2013). Almost two decades ago, Mohl (2001) concluded that "a middle to long-term disappearance of the Little Tern in Croatia can be expected if the ongoing impact of the water management in Croatia is not stopped".

The main threats, channelling of the river and upstream hydropower plants, changed natural dynamics of the water level and caused a reduction of gravel sediment in the river. They were already identified as the main threats to the Sava River (Schwarz 2016). Changes in river management as well as restoration projects are needed to preserve the natural flow of the Sava River. An assessment of the restoration potential of the Sava River showed very high or high potential of the river stretch upstream and downstream from Zagreb (Schwarz 2016). Restoration projects should allow lateral erosion in adjacent floodplain areas, resulting in development of gravel bars and islands. Without restoration projects, prevention of further deterioration of the river course and proper management, the Natura 2000 site "Sava kod Hrušćice" will completely lose habitats needed to support the species for which it was designated.

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4. Povzetek

Med letoma 2002 in 2019 je potekal monitoring navadne čigre *Sterna hirundo* in male čigre *Sternula albifrons* ob Savi v okolici Zagreba. Natura 2000 območje "Sava kod Hrušćice" je bilo razglašeno z namenom varovanja kolonije na rečnih otokih. Ocenjena velikost tamkajšnje populacije je bila 100−150 parov navadne in 20 parov male čigre. Zaradi poplavljanja otokov so kolonije pogosto propadle. Okoli 150 parov navadne čigre je zato za nadomestno gnezdišče izbralo otoke v gramoznicah, medtem ko mala čigra po letu 2010 ne gnezdi več. V zadnjem letu čigre na Hrušćici niso gnezdile, edino zasedeno območje znotraj območja Natura 2000 je bil splav v gramoznici Siromaja. Regulacije rek in gradnje hidroelektrarn so glavne grožnje za čigre, saj spreminjajo naravno dinamiko in zmanjšujejo prenos proda po reki.

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Area use and important areas for Common Tern *Sterna hirundo* inland populations breeding in Slovenia and Croatia

Raba območij in pomembna območja celinske populacije navadne čigre *Sterna hirundo* v Sloveniji in na Hrvaškem v času gnezdenja

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During the breeding periods of 2018 and 2019 we investigated the extent of areas Common Terns *Sterna hirundo* use while searching for food. We used GPS-UHF tags to follow the movements of 23 terns from Slovenia (7 individuals) and Croatia (16 individuals). We investigated the movements of birds from three breeding sites, i.e. Lakes Ptuj, Siromaja 2 and Rakitje. Conclusions are based on 43,105 locations which were collected with a frequency of one reading per 20 minutes during the day and one reading per 4 hours during the night.
In Slovenia, terns used a 60 km long and narrow area over Stara struga Drave (former river-bed of the Drava River) between Ormož and Maribor as well as eleven fishponds / lakes in its surroundings, most of them in the Pesnica valley. The most distant location was 30 km of straight line from breeding islands, but it was visited only once by a single tern. The areas with the most locations, hence important areas, were Lake Ptuj, Drava at Ptuj, Stara struga Drave between Ptuj and Rošnja and about 20 km distant Lakes Radehova and Gradiško. These were probably the most important feeding areas for Common Terns breeding on Lake Ptuj.
In Croatia, terns were found along the Sava almost exclusively, with only a few visits more than 2 km from the river. The most distant locations were over 60 km away from the breeding grounds, but terns visited them only rarely. Most locations of terns nesting on Siromaja were within a 5 km radius, while terns from Rakitje were making regular flights to waters up to 23 km from their colony. The area with the most locations visited by terns from both colonies was the Sava at Hruščica. Besides, birds from the Rakitje colony were frequently recorded on the Sava near Savica and waterbodies within 5 km of the colony. These were probably the most important feeding areas for Common Terns breeding around Zagreb.

Key words: Common Tern, foraging areas, GPS-UHF tags, home range, Drava, Sava
Ključne besede: navadna čigra, območja prehranjevanja, GPS-UHF oddajniki, Drava, Sava

1. Introduction

Bird abundance and distribution is limited by suitable habitats. Among the most important factors affecting habitat suitability are quality of nest-site, food supply and "enemies", being predators, parasites or competitors (Newton 2007). Common Terns *Sterna hirundo* nest close to large water bodies on flat, scarcely vegetated surfaces (Nisbet 2002). Sea coast seems like a very spacious breeding area for them, but only very specific habitats meet all criteria for nest-site selection. In Croatia, for example, although abundant with sea coast, only 200–500 pairs are presumed to nest along the sea (Kralj *et al.* 2013). In marine ecosystems in Slovenia, terns nest at artificially maintained Sečovlje saltpans and in carefully managed Škocjanski zatok Nature Reserve (Škornik 2012).

Inland, the most often occupied natural breeding sites of Common Terns are gravel islands and banks in the areas of large rivers and lakes, where predators have limited access (Becker & Ludwigs 2004). Nowadays, due to countless changes made in freshwater ecosystems by humans, these are among the rarest and most endangered habitats in Europe (EEA 2015). Hence terns are more and more diverted to nest in artificial areas and structures like gravel pits and nesting rafts. In Slovenia, the only permanent breeding site of Common Terns are artificial islands on Lake Ptuj on the Drava River (Denac *et al.* 2019), where they've nested since the reservoir was created in 1978 (Janžekovič & Štumberger 1984). In 2017, another breeding island was created on Brežice HPP reservoir on the Sava River. Common Terns bred there in 2018 and 2019, but whether this is to become another regular breeding site for Slovenia remains to be seen. In Croatia, regularly nesting terns can be found on two locations near the Sava River (Hrušćica and Rakitje) and two on the Drava (Lake Ormož and Drava River close to Repaš), while occasional breeding in smaller numbers also occurs at various fishponds of continental Croatia. The population of inland breeding Common Terns in both countries is estimated at 300–500 breeding pairs. Being so scarce and vulnerable, most breeding sites are strictly protected by law (Božič 2003, Radović *et al.* 2005) and well managed (Denac & Božič 2018, Martinović 2018). Still, to run an efficient protective breeding program for Common Terns, other factors important for suitability of the habitat should be controlled, too, in particular food. In Slovenia and Croatia, there have been no reports in this respect, beside notes on sporadic observations of terns foraging on different locations during the breeding season (e.g. Vogrin 2016).

While breeding and when not on or near the nest, Common Terns spend a lot of their time flying over shallow waters, where they search for food, mainly fish up to 15 cm long (Becker & Ludwigs 2004), which they catch by plunge-diving from the air (Holbech *et al.* 2018). Beside for themselves, they use the catch for feeding their unfledged chicks. Since this means collecting food at some distant sources and carrying it to a nest (usually one by one), that makes them "central place foragers" (Wetter 1989, Dänhard *et al.* 2011). The optimal foraging theory predicts that the distance to which they fly during the hunt is somehow limited by economics (Pyke 1984) – they can afford longer flights if food there is more abundant, easier to catch or energetically more profitable. But in general, the radius of activity of breeding terns is usually between 3 and 10 km, exceptionally up to 30 km (Nisbet 2002) from the nest.

Locations of nests, numbers and breeding success are relatively well known for inland populations of Common Tern in Slovenia and Croatia (Kralj 2018, Mihelič *et al.* 2019). On the other hand, food and feeding habits are virtually unknown, so we designed this study to complement our knowledge appropriately. Our aim was (1) to find the whole extent of areas adult terns use during the breeding season (area use) and (2) to find which are the most used ones (i.e. most important). Since we did not observe the terns physically, we only presume that the majority of activities when not on or by the nest were to locate and catch the prey (feeding activity), although we realize that some were also due to other needs, like flying, prospecting, etc. (Martinović *et al.* 2019).

2. Study area

2.1. Slovenia

In Slovenia, the study was conducted on Lake Ptuj, where Common Terns nest, and in its surrounding areas (Figure 1). Lake Ptuj is an artificial water

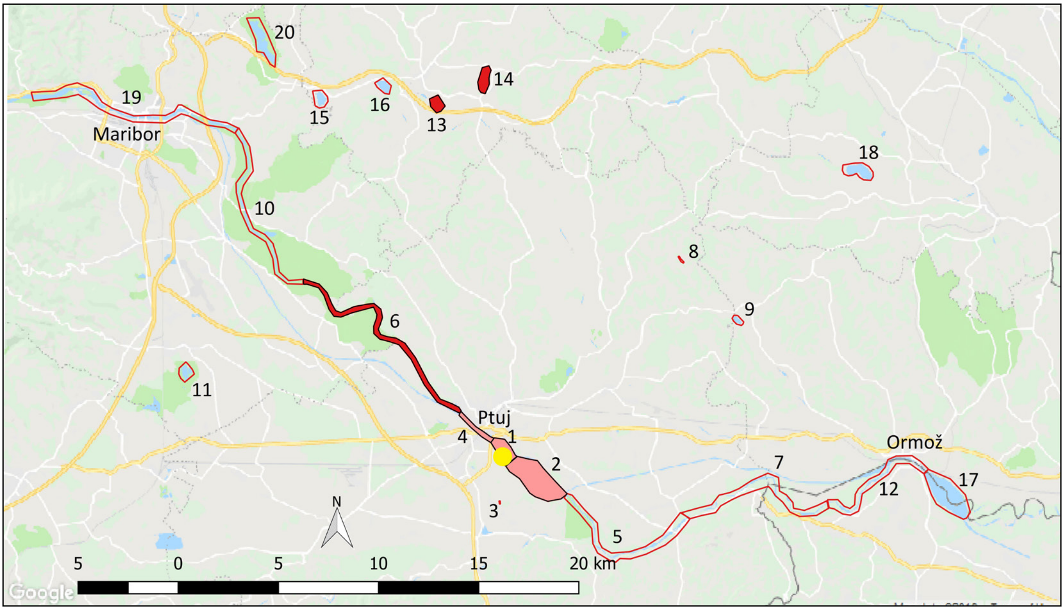

Figure 1: Areas used by Common Terns in Slovenia are presented with outlined polygons. Numbers correspond to numbers in Table 2. Filled in red important foraging areas, filled in pink important areas for foraging and as flying corridors. Yellow circle denotes position of breeding island.

Slika 1: Raba območij navadnih čiger v Sloveniji, označena s poligoni. Številke ustrezajo območjem v tabeli 2. Rdeča so območja, pomembna za prehranjevanje, rožnata pa območja, pomembna za prehranjevanje in kot preletni koridorji. Rumeni krog označuje položaj gnezdišča.

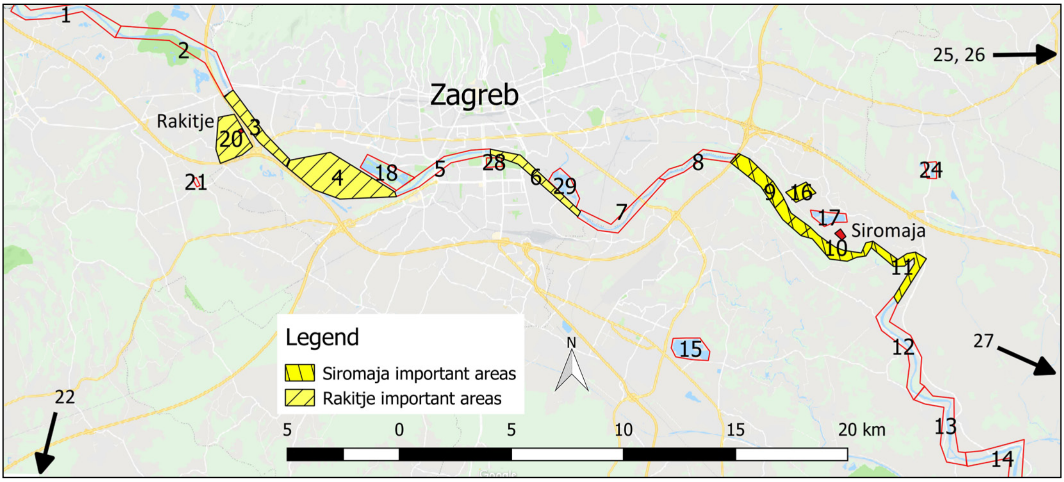

Figure 2: Areas used by Common Terns in Croatia are presented with outlined polygons. Numbers correspond to numbers in Tables 3 and 4. Important foraging areas are filled in yellow, with crossbars indicating the colony for which these areas are deemed important (see Legend). Breeding colonies are filled in red.

Slika 2: Raba območij navadnih čiger na Hrvaškem, označena s poligoni. Številke ustrezajo območjem v tabelah 3 in 4. Rumena so območja, pomembna za prehranjevanje z različnimi šrafurami za obe koloniji (glej legendo). Rdeči poligoni označujejo položaj gnezdišč.

body constructed in 1978 on the Pannonian stretch of the Drava River as reservoir for the channel-type hydropower plant Formin. It is 7.3 km long and 1.2 km wide, with its surface area covering 346 ha. In recent years, terns have been nesting there on two gravel islands (both covering 1,100 m^2) constructed in 2014, while other islands are occupied mainly by Black-headed Gulls *Larus ridibundus* (Božič & Denac 2014).

To the north of the lake spreads the town of Ptuj, while other parts of its surroundings are mostly intensive cultural landscapes with many fields, some hedgerows and villages. About 19 km further north is a series of seven lakes in the Ščavnica and Pesnica valleys. About 18 km to the W is a series of fishponds near the village of Rače and Medvedce reservoir. In other directions within this perimeter are some other small fish ponds, mostly without official names. The Drava River represents both the inflow and the outflow to and from Lake Ptuj. The original riverbed is in both sections complemented with an artificial, concrete channel, used to bring water to the power plant. Most of the water throughout the year is diverted to the channel, leaving the riverbed with only a small volume of water flow (20 m^3/s upstream and 10 m^3/s downstream of Lake Ptuj during the Common Tern breeding season).

2.2. Croatia

The Croatian part of the study was conducted along the Sava River in the surroundings of Zagreb (Figure 2). Terns were tagged on Lake Siromaja 2, a gravel pit with a floating breeding platform about 15 km downstream (SE) from the city of Zagreb, and on Lake Rakitje just off the W edge of Zagreb with a fairly large colony on an artificial island. The Sava River is mostly regulated and canalized all the way through Zagreb, with semi-natural flows upstream from Rakitje, about 10 km to the Slovenian border, as well as downstream from Ivanja Reka (Slukan Altić 2010). The part downstream from Ivanja Reka is protected as a Natura 2000 site "Sava kod Hrušćice" (Radović *et al.* 2005.), and this area includes numerous small gravel pits, including Siromaja 2. There are numerous other gravel pits all along the Sava through and around Zagreb. The air distance between Siromaja 2 and Rakitje lakes is 27 km and 31.5 km along the river.

3. Material and methods

3.1. Field work

We used the GPS-UHF solar-powered Nano-tags produced by Milsar, attached to birds with Teflon chest harness, to collect data on the movements by Common Terns. The device with harness weighed about 4 g, representing about 3.5% of body mass of the tern. While fitting the tags, we also marked the birds with stainless steel on one and plastic ring on the other leg.

Adults were captured on the nest using nest traps as late as possible during the incubation period. According to observations from a distance and some visits to the breeding colony, not all terns with tags successfully fledged their chicks. If a tagged bird deserted the nest before chick was hatched or in case of malfunction of the tag, the collected data was not included in the analysis.

Loggers collected GPS fixes every 20 min during daylight (4 am to 10 pm) and every 4 hrs during nighttime. GPS location accuracy was 10 m for 90% of the records (manufacturer specifications). We regularly downloaded data to a computer using an omnidirectional antenna connected to a base station.

3.2. Data analysis

We define a location as a single geographic coordinate recorded by a tag. We used Google Earth and QGIS (QGIS Development Team 2016) to graphically present distribution of all locations of all terns within the study site. As expected, locations were clustered around different water bodies (rivers, lakes, submerged gravel pits, fish ponds, etc.). We visually defined each cluster within separate water body as a separate area. In Slovenia, large areas (in particular long water courses) were further separated into two or three smaller sub-areas (in the text referred to as "the area" for sub-areas too). In Croatia, the Sava River was divided into 14 segments, each of roughly 5 km in length. Additionally, as a nesting area, we defined islands or rafts where Common Terns nested, even if they were located within one of the larger areas.

We used MS Excel to analyze distribution of locations according to the defined areas. Each area was geo-fenced with a four corner polygon. For each location and each line of the polygon, we computed the value

d=(x–x1)(y2–y1)–(y–y1)(x2–x1)
(x, y = coordinates of location; x1,y1 = coordinates of one end of the line; x2,y2 coordinates of the other end of the line)

to determine on which side of the line is the given location. If d > 0 the location was on one side, if d < 0 the location was on the other side, and if d = 0 the location was exactly on the line. The final result after testing for all four lines of a particular polygon was information whether the location was inside or outside the polygon surrounding a specific area.

To find which areas within home range were most often used, hence important for Common Terns (beside nesting area which was regarded as important by default), we first removed all locations from within the nesting area. For remaining locations, we used three aspects to highlight the level of importance of particular area:

(1): Cumulative number of locations of all terns in a specific area. Subjectively we considered the area as an important site if it contained more than 10% of all locations.
(2): The number of terns detected within a specific area. Subjectively we considered an area as a candidate for an important site if more than half of terns (4 for Slovenia, 2 for Croatia-Rakitje and 6 for Croatia-Siromaja) had at least one location within a specific area.
(3): Number of terns commonly present in a specific area. As commonly present we considered birds with at least 10% of locations in the particular area. With this aspect also birds with short monitoring period influence a selection of important areas. A candidate for an important site should have at least one regular visitor.

In the end we defined an area as an important site for Common Terns during the breeding season if it corresponded with the first aspect or if it was a candidate according to both other aspects.

4. Results

We analyzed data from 23 loggers (7 in Slovenia and 16 in Croatia) which were collecting locations of terns for 5 or more consecutive days (Table 1). In Slovenia, loggers attempted to record location 10,781 times. In 631 of these attempts (5.8%), GPS unit failed to connect to satellites within the pre-programmed time and record coordinates, or the registered location was erroneous. The rest were valid locations. 701 valid locations (6.9%) were disregarded due to being outside the selected areas mostly from birds recorded while flying from breeding areas over land to foraging areas or

Table 1: Statistics of tracking effort of Common Terns with GPS tags; CN = individual code number of the tern, CO = country, FD = date of first record; LD = date of last record; NR = Number of readings

Tabela 1: Statistika zbiranja GPS podatkov na navadni čigri; CN = individualna koda osebka, CO = država, FD = datum prvega podatka; LD = datum zadnjega podatka; NR = število podatkov

CN	CO	FD	LD	NR
961002	SI	5/27/2018	7/21/2018	2019
961003	SI	5/19/2018	7/11/2018	2313
961004	SI	5/19/2018	7/2/2018	1809
961007	SI	5/19/2018	5/23/2018	184
961009	SI	5/23/2018	5/27/2018	239
961014	SI	5/23/2018	7/2/2018	1897
961020	SI	5/20/2019	6/15/2019	988
961020	CRO	6/20/2018	7/19/2018	1535
961021	CRO	6/5/2018	7/20/2018	2634
961022	CRO	6/6/2018	8/1/2018	2470
961023	CRO	6/5/2018	7/12/2018	1082
961024	CRO	6/5/2018	7/26/2018	2894
961025	CRO	6/17/2018	8/1/2018	1758
961026	CRO	6/11/2018	7/20/2018	1061
961028	CRO	6/26/2018	8/12/2018	2315
961029	CRO	6/5/2018	8/1/2018	2720
961030	CRO	6/8/2018	7/12/2018	2085
961031	CRO	6/8/2018	7/20/2018	2387
961032	CRO	6/8/2018	7/19/2018	2372
961033	CRO	6/8/2018	8/1/2018	2905
961034	CRO	6/11/2018	7/26/2018	2308
961035	CRO	6/11/2018	7/20/2018	1490
961036	CRO	6/11/2018	7/14/2018	1690

Table 2: Number of locations in particular areas for Common Terns from Lake Ptuj. Area – geographic name of the area (RD – former Drava river-bed); distance – from breeding island/raft to centroid of the area; % locations – percentage of locations (according to column "all terns"); N >= 10% – number of terns with >= 10% of locations in particular area (common visitors of the area); N – number of terns recorded in the area. Shaded are important areas and numbers reaching the threshold for selection of important area.

Tabela 2: Število lokacij v posameznih območjih za čigre s Ptujskega jezera. Area – ime območja (RD – stara struga Drave); distance – razdalja med gnezdiščem in centroidom območja; % locations - odstotek lokacij (iz kolone "all terns"); N = 10 % . število čiger, ki so imele >= 10 % lokacij v izbranem območju (redne obiskovalke); N – število čiger, zabeleženih v območju. Osenčena so pomembna območja za čigre in vrednosti, ki dosegajo mejo za določanje pomembnih območij.

	Area		Code number of individual tern								statistics			
		distance (m)	961002	961003	961004	961007	961009	961014	961020	all terns	% locations	N >=10%	N	Cummulative %
	breeding islands	0	1035	654	1132	87	111	261	700	3980	100,0			
1	lake Ptuj - N	800	258	273	55	45	30	114	41	816	14.9	5	7	14.9
2	lake Ptuj - S	1700	59	544	29	9	0	3	21	665	12.2	1	6	27.1
3	fish pond near Ptuj	2000	57	2	0	0	0	0	0	59	1.1	0	2	28.2
4	Drava at Ptuj	2100	187	129	5	4	34	94	49	502	9.2	3	7	37.3
5	RD Markovci to Ormož - E	5500	1	31	0	1	0	1	0	34	0.6	0	4	38.0
6	RD Ptuj - Rošnja	7600	269	378	5	13	59	1147	176	2047	37.4	6	7	75.4
7	RD Markovci to Ormož - C	9500	0	1	0	0	0	2	0	3	0.1	0	2	75.4
8	fish ponds at Bodkovci	13200	1	89	0	0	0	0	0	90	1.6	0	2	77.1
9	lake Savci	13500	1	36	0	0	0	0	0	37	0.7	0	2	77.8
10	RD Rošnja - Maribor	15700	1	2	0	0	5	11	0	19	0.3	0	4	78.1
11	fish ponds at Rače	16500	1	103	0	0	0	0	0	104	1.9	0	2	80.0
12	RD Markovci to Ormož - W	16500	0	4	0	3	0	13	0	20	0.4	0	3	80.4
13	lake Radehova	19000	129	0	406	10	0	198	0	743	13.6	4	4	94.0
14	lake Gradiško	19500	10	0	87	5	0	46	1	149	2.7	1	5	96.7
15	lake Pristava	21000	1	0	6	0	0	6	0	13	0.2	0	3	96.9
16	lake Komarnik	21200	0	0	3	0	0	0	0	3	0.1	0	1	97.0
17	lake Ormož	22000	0	32	0	7	0	1	0	40	0.7	0	3	97.7
18	Gajševsko lake	23000	0	22	0	0	0	0	0	22	0.4	0	1	98.1
19	Drava at Maribor	25000	0	13	0	0	0	0	0	13	0.2	0	1	98.4
20	lake Pernica	25000	9	0	81	0	0	0	0	90	1.6	1	2	100.0
	all areas w/o breeding islands		984	1659	677	97	128	1636	288	5469				

vice versa. In Croatia there were 38,172 recording attempts, 1,186 (3.1%) of them failed to record valid coordinates, 3,421 (9.2%) valid records were disregarded for the same reason as in Slovenia. After exclusion of erroneous and disregarded readings, we were left with 43,105 locations used for analysis (9,449 in Slovenia and 33,565 in Croatia).

4.1. Slovenia

In Slovenia, we determined 21 areas of activity (Figure 1, Table 2). One area was composed of two breeding islands, located within the larger area of Lake Ptuj. The most distant areas from breeding islands were Lake Pernica (20 in Table 2) and the Drava River at Maribor (19), which both have centroids about 25 km of straight line from breeding islands.

A little more than 42% of analyzed locations were from breeding islands (Table 2). More than one third of the remaining recordings were from the Drava Riverbed between Ptuj and Rošnja (6 in Table 2; 2,047 locations or 37%) which was, beside breeding islands, the most used area. From the section of the Drava river-bed between Rošnja and Maribor (10) there were only 19 recorded locations.

Within Lake Ptuj (without breeding islands), terns were documented 1,481 times (27% of locations), with the N part of the lake (1) having only marginally more locations than the S part (2; 815 or 15% compared to 665 or 12%). The only other area with over 10% of locations was Lake Radehova (13; 743 locations or 14%), while the Drava at Ptuj (4) came very close to 10% threshold (502 locations or 9%).

Of the remaining areas, Lake Gradiško (14), fish ponds at Rače (11), small fishponds at Bodkovci (8), Lake Pernica (20) and a small fish pond near Ptuj (3) each had more than 1% of locations. The remaining ten areas combined had 3.6% locations. The entire Stara struga Drave between Markovci and Ormož, although more than 20 km in length, had only 57 locations.

The part of the Drava river-bed between Ptuj and Rošnja (6), the Drava at Ptuj (4) and N part of Lake Ptuj (1) were used by all 7 terns, although the percentage of locations was rather unequally distributed among individual birds (from 1% to 70%). Five or six birds used the S part of Lake Ptuj (2), the part of Stara struga Drave between Rošnja and Maribor (10) and Lake Gradiško (14). Four birds used the E part of Stara struga Drave between Markovci and Ormož (5), as well as Lake Radehova (13). Two areas with a relatively high number of locations, a small fish pond at Bodkovci (8) and fish ponds at Rače (11), were used mostly by one bird only (individual code number 961003). This bird was responsible for 99% of all locations in these two areas.

The areas where at least one tern was commonly present were: Lake Ptuj (1,2), the Drava at Ptuj (4), part of Stara struga Drave between Ptuj and Rošnja (6), Lake Gradiško (14), Lake Radehova (13) and Lake Pernica (20).

4.2. Croatia

Results from colonies around Zagreb are shown in Tables 3 and 4 and Figure 2. We identified 28 areas where terns were recorded during the study (20 for birds breeding on Siromaja 2 and 24 for birds breeding on Rakitje). Two were the breeding colonies themselves, although each also served as a visiting area for birds from the other colony. The Rakitje colony was itself situated within the larger Lake Rakitje (20 in Tables 3 and 4). The most distant areas from breeding islands were Sišćani (26) and Garešnica-Poljana fishponds (27), the former with a centroid of about 60 km of straight line from Rakitje, and the latter about 65 km from Siromaja 2.

For birds breeding on Siromaja, 70.9% of all GPS fixes were within boundaries of the colony lake. Almost half of all other fixes were on the Sava at Hrušćica (9). The next most popular sites were Abesinija Lake (16), the Sava at Siromaja (10) and the Sava at Rugvica (11). The remaining 23 areas accounted for only 6.4% of locations outside the colonies.

Birds breeding at the Rakitje colony had 57.0% of all GPS locations at the colony itself. They also had the highest share of their non-colony fixes, one quarter of them, on the Sava at Hrušćica (9). Rakitje Lake (20) was the next most popular site, while the rest of the locations were slightly more evenly scattered along the Sava River, most notably the Sava near Savica (6) and the Sava at Blato (4). More than a quarter of non-colony locations were spread out along the seven other areas of the Sava between Strmec and Rugvica, as well as on Lakes

Table 3: Number of locations in particular areas for Common Terns from Siromaja 2. Abbreviations the same as in Table 2.

Tabela 3: Število lokacij v posameznih območjih za čigre s Siromaje 2. Okrajšave enake kot v tabeli 2.

	Area								
		distance (m)	961021	961023	961024	961026	961029	961030	961031
	Siromaja colony		2160	667	1794	898	1506	1769	2134
10	Sava at Siromaja	700	125	34	234	35	152	85	58
17	Rugvica lakes	1000	3	2	27	4	5	3	2
16	Abesinija lake	2700	5	268	326	22	220	9	7
11	Sava at Rugvica	3100	48	18	4	32	45	4	67
9	Sava at Hrušćica	3900	274	35	509	68	750	211	92
12	Sava Novaki-Oborovo	5500	3	6	0	1	1	0	0
8	Sava at Ščitarjevo	7200	4	2	0	1	4	1	0
15	Čiče lake	8200	0	0	0	0	37	0	0
13	Sava Oborovo-Prevlaka	9400	1	0	0	0	0	0	0
7	Sava at Petruševec	9700	3	3	0	0	0	2	3
14	Sava Prevlaka-Prerovec	13500	0	1	0	0	0	0	0
6	Sava near Savica	14500	6	3	0	0	0	1	1
5	Sava Jarun-Bundek	18000	0	1	0	0	0	0	2
4	Sava at Blato	23100	0	3	0	0	0	0	11
3	Sava at Rakitje	26500	0	2	0	0	0	0	0
	Rakitje colony	27100	0	17	0	0	0	0	5
20	Rakitje lake	27500	0	3	0	0	0	0	0
21	Kerestinec	28800	0	0	0	0	0	0	0
27	Garešnica-Poljana fishponds	65200	0	0	0	0	0	0	0
	all areas w/o colony		472	398	1100	163	1214	316	248

Abesinija (16) and Jarun (18). The remaining 15 areas made up the remaining 3.8% of non-colony locations.

The Sava at Siromaja (10), Rugvica lakes (17), Abesinija Lake (16), the Sava at Rugvica (11) and the Sava at Hrušćica (9), all within 5 km of the colony on Siromaja 2, were used by all 12 birds breeding there. They spent a vast majority of their time (94.1% of all locations) in these areas closest to their colony. All five remaining parts of the Sava River between Savica and Prevlaka, within 15 km of the colony, were used by half or more of the tagged birds, although far less regularly (3.7% of all locations). The Sava at Hrušćica (9), the Sava at Siromaja (10), the Sava at Rugvica (11) and Abesinija Lake (16) were the only areas commonly used by birds breeding on Siromaja 2.

A much larger number of areas, 12 of them, were used by all four birds breeding at Rakitje. A further 7 were used by two or more birds, completing the entire stretch of the river from the Slovenian border to Prevlaka. Apart from the most popular areas the Sava at Hrušćica (9), Rakitje Lake (20), the Sava near Savica (6) and the Sava at Blato (4), one bird was present commonly on the Sava at Rakitje (3), and another at Abesinija Lake (16).

Code number of individual tern									statistics
961032	961033	961034	961035	961036	all terns	% locations	N	>=10%	Cummulative %
1377	2050	1529	932	1316	18132	100.0			
82	107	178	181	37	1308	17.6	12	10	17.6
14	11	9	3	1	84	1.1	12	0	18.7
499	53	116	7	7	1539	20.7	12	6	39.5
178	128	28	66	48	666	9.0	12	7	48.4
161	442	419	287	142	3390	45.6	12	11	94.1
8	11	6	2	4	42	0.6	9	0	94.6
1	12	4	0	11	40	0.5	9	0	95.2
0	0	13	11	5	66	0.9	4	0	96.0
8	25	2	1	1	38	0.5	6	0	96.6
4	32	2	0	20	69	0.9	8	0	97.5
3	2	1	0	0	7	0.1	4	0	97.6
3	1	1	0	7	23	0.3	8	0	97.9
2	0	0	0	3	8	0.1	4	0	98.0
3	0	0	0	2	19	0.3	4	0	98.3
4	0	0	0	8	14	0.2	3	0	98.4
11	0	0	0	29	62	0.8	4	0	99.3
3	0	0	0	15	21	0.3	3	0	99.6
0	0	0	0	2	2	0.0	1	0	99.6
0	31	0	0	0	31	0.4	1	0	100.0
984	855	779	558	342	7429				

5. Discussion

A little more that 42% of locations obtained by tags in Slovenia were from breeding islands, while terns spent more time in Croatian colonies (70.9% on Siromaja 2 and 57% on Rakitje). To some point the number of locations on breeding islands is a consequence of the time when terns were caught and fitted with the tag. Our aim was to do this as late during incubation period as possible, preferably in the last two days of incubation. To minimize disturbance, we did not monitor the colony on a daily basis, so we were not able to determine hatching day/last days of incubation period with great precision. The earlier we caught the terns during incubation period, the more days it spent incubating the eggs, which increased the number of locations from this area. This rationale might seem to clash with data from Croatia: birds from the Rakitje colony were tracked from the first day of nesting because they had been equipped with devices beforehand on Lake Siromaja 2. Birds breeding at Siromaja 2, on the other hand, were tagged in mid-incubation and yet they had more colony points than birds at Rakitje. A possible cause for that might be polygon outlining – the Siromaja 2 colony polygon includes the entire lake since smaller platform size, GPS error and lake size led to "colony" points being scattered across almost half of the lake, while the Rakitje and Ptuj colony polygons included only the breeding islands. It is thus inevitable to surmise that Siromaja 2 points include foraging activity as well, while Rakitje and Ptuj colony points include only breeding activity and resting.

At any rate, breeding islands that were determined by us as separate areas within Lakes

Table 4: Number of locations in particular areas for Common Terns from Rakitje. Abbreviations the same as in Table 2.

Tabela 4: Število lokacij v posameznih območjih za čigre z Rakitja. Okrajšave enake kot v tabeli 2.

	Area		Code number of individual tern								statistics
		dis-tance (m)	961020	961022	961025	961028	all terns	% loca-tions	N	>=10%	Cum-mula-tive %
	Rakitje colony		772	999	1299	1492	4562	100.0			
20	Rakitje lake	500	74	399	23	59	555	16.1	4	2	16.1
3	Sava at Rakitje	700	21	61	95	38	215	6.2	4	1	22.4
21	Kerestinec	2900	0	6	0	0	6	0.2	1	0	22.5
2	Sava at Strmec & Orešje	4000	3	16	25	2	46	1.3	4	0	23.9
4	Sava at Blato	4700	34	127	51	136	348	10.1	4	2	34.0
18	Jarun lake	6800	3	14	7	17	41	1.2	4	0	35.2
5	Sava Jarun-Bundek	9100	23	65	26	40	154	4.5	4	0	39.7
1	Sava 1	9700	0	3	7	0	10	0.3	2	0	39.9
5	Bundek	11300	0	7	1	3	11	0.3	3	0	40.3
6	Sava near Savica	13100	28	210	65	104	407	11.8	4	3	52.1
29	Savica reserve	14700	0	2	0	4	6	0.2	2	0	52.3
7	Sava at Petruševec	17400	51	99	24	77	251	7.3	4	0	59.6
8	Sava at Ščitarjevo	20500	12	32	14	13	71	2.1	4	0	61.6
22	Crna Mlaka fishponds	22700	0	3	3	0	6	0.2	2	0	61.8
9	Sava at Hrušćica	23700	186	375	76	215	852	24.8	4	4	86.5
10	Sava at Siromaja	23700	37	42	18	32	129	3.7	4	0	90.3
16	Abesinija lake	25200	89	0	0	0	89	2.6	1	1	92.9
	Siromaja colony	27100	25	2	0	54	81	2.4	3	0	95.2
11	Sava at Rugvica	27500	42	8	9	20	79	2.3	4	0	97.5
12	Sava Novaki-Oborovo	30200	3	0	4	8	15	0.4	3	0	98.0
24	Puhovec lakes	30900	36	0	0	0	36	1.0	1	0	99.0
13	Sava Oborovo-Prevlaka	31100	0	0	9	1	10	0.3	2	0	99.3
26	Sišćani fishponds	66400	24	0	0	0	24	0.7	1	0	100.0
	all areas w/o colony		691	1471	457	823	3442				

Ptuj and Rakitje and the entire Siromaja 2 Lake, are, for obvious reasons, regarded as important for Common Terns by default, regardless of the number of recorded locations. We excluded those data for the analysis of other areas, so that a difference in the number of days terns spent incubating eggs did not influence further results.

As expected, area use of terns during breeding season relates closely to large water bodies like rivers, lakes and fishponds.

In Slovenia, some areas were dislocated from Lake Ptuj. Terns reached them only after flying up to 26 km over cultural landscape, where they crossed villages, highways and small forest patches. Sequences of locations showed that they were following the route in a rather straight line, indicating that they must have had previous experience about the location. The largest and continuous part of used area stretched along the Drava from Lake Ormož to Maribor. This is about 60 km long and very narrow part which terns seem to exploit simply by following the course of the Drava River. The most remote location from nesting ground was the Drava close to the village of Bresternica, NW of Maribor. It was about 30 km of straight line from nesting ground and was visited once by one tern only.

The most used areas (beside nesting islands) were the Drava river-bed between Ptuj and Rošnja, the Drava at Ptuj and Lake Ptuj. These are all neighbouring areas, together forming a large important area, which also includes breeding islands. Two areas that were almost 20 km of straight line away from the Drava, Gradiško Lake and in particular Lake Radehova, turned out to be important as well. The latter was used by 5 terns, four of which were commonly present in the area . As expected, the artificial channel with fast and deep water flow, which runs almost parallel to the Drava river-bed, turned out to be a totally inappropriate habitat for terns.

Compared to birds from Ptuj, terns in Croatia usually stayed much closer to the Sava River, very rarely straying more than 2 km from the river. The single most important area for birds from both Croatian colonies was part of the Sava River at Hruščica, which is not surprisingly a Natura 2000 protected area (Radović *et al.* 2005.). Apart from breeding within the boundaries of this Important Bird Area, 85% of localities of birds from the Siromaja colony were there as well, aligned along the river or at Lake Abesinija, and another 9% immediately downstream. Even birds from the Rakitje colony regularly travelled 25 km to have a third of their locations there. Other areas identified as important for birds breeding on Rakitje were the Sava near Savica and, closer to their own colony, the Sava at Blato and the Sava at Rakitje, as well as Lake Rakitje itself.

There is a catch in our data which should be considered when interpreting the results. While tags gave us relatively exact locations of terns in exact time, there was no way we could read from them what they were doing while on the location. For locations within nesting area we can more or less accurately say that birds were involved in breeding routine, whether incubating the eggs or caring for their chicks. A certain proportion of readings from this area was possibly also recorded during resting time. On the other hand, it is impossible to interpret activities of terns in other locations with such ease. But we believe that the majority of them belong to two types of activity: hunting (catching and searching for prey) and flying.

Several locations outside the nesting site were definitively recorded during hunting activity, but some were almost certainly recorded also during flights, when terns were on their way to reach more distant hunting areas. In practice this means that some locations on Lake Ptuj and on the Drava at Ptuj were possibly obtained during flights to a hunting place on the Drava river-bed between Ptuj and Maribor and not during a hunt. The ratio between flying and hunting activity is impossible to quantify, but we presume that a higher proportion of flying activity was recorded closest to the nesting area than in more distant areas. It is thus possible that importance of some areas near the nesting place is both as a flying corridor toward hunting locations as well as a hunting area itself, while more distant ones probably had greater proportion of hunting activities as opposed to flying.

With this in mind, we believe that the most important hunting areas for Common Terns in Slovenia were the Drava river-bed from Ptuj to Rošnja, Gradiško Lake and Lake Radehova. Lake Ptuj and the Drava at Ptuj were definitely important as flying corridors and, to a certain level, as hunting areas too. The latter is confirmed by regular observations of terns foraging in these areas.

Taking this into account with Croatian colonies, the importance for terns breeding at Rakitje of the far-away Sava at Hrušćica becomes even more obvious, and to a lesser extent that of the Sava near Savica. On the other hand, the Sava at Rakitje and the Sava at Blato both probably serve a dual purpose of feeding area and flight corridor.

Common Terns mostly fish within 3 to 10 km of the breeding grounds, with longest foraging distances being over 30 km (Becker & Ludwigs 2004). The longest distances to the most frequently visited areas in this research were in this range, although rather different between locations: from 4 km at Siromaja, to 20 and 24 km in Ptuj and Rakitje, respectively. The overall longest distance (it was made by two terns) was stunning 65 km. This distance corresponds roughly to the distance between Slovenian and Croatian breeding colonies at Ptuj and near Zagreb. Nevertheless, we did not find any evidence that terns from these colonies were in any kind of contact. On the other hand, results showed possible interactions between terns from the colony at Ptuj with the ones on Croatian side of Lake Ormož. Also, although not a single location of terns from Croatia was found on Slovenian side of the Sava, recoveries of ringed birds (Archives of Ringing Centers Zagreb and Ljubljana) showed that terns from Rakitje and Blato colonies do disperse to the colony on the Sava near Brežice.

We recommend conducting further studies of how environmental factors such as hydrology and productivity influence area use. These are necessary in order to explain why areas like the Sava at Hrušćica and the Sava near Savica in Croatia, and Gradiško and Radehova Lakes in Slovenia are so favourable that birds are willing to fly 20–25 km to reach them instead of staying closer to their colony. More detailed analyses of home range are also necessary.

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6. Povzetek

V sezonah 2018 in 2019 smo raziskovali območja, ki jih navadne čigre (*Sterna hirundo*) obiskujejo med gnezdenjem. Z GPS-UHF-oddajniki smo sledili 23 čiger iz Slovenije (7 osebkov) in Hrvaške (16 osebkov). Ptice smo ujeli na treh gnezdiščih: Ptujsko jezero, Siromaja 2 in Rakitje. Zaključki so narejeni na osnovi 43.105 podatkov o lokacijah, ki smo jih zbirali s frekvenco en odčitek na vsakih 20 minut podnevi oz. en odčitek na vsake 4 ure ponoči.

V Sloveniji so čigre letale nad 60 km dolgim, ozkim območjem Drave od Ormoža do Maribora in nad enajstimi ribniki / jezeri v okolici, večinoma v dolini Pesnice. Najbolj oddaljena lokacija od gnezdišča je bila 30 km v ravni črti, a tako daleč se je odpravila le ena čigra, in to enkrat samkrat. Najpogosteje so se čigre zadrževale na stari strugi Drave med Ptujem in Rošnjo, na Ptujskem jezeru, na Dravi pri Ptuju ter na jezerih Radehova in Gradiško. Slednji sta oddaljeni okoli 20 km od gnezdišča. To so bila v celinskem delu Slovenije verjetno najpomembnejša območja, na katerih so čigre v času gnezdenja iskale hrano.

Na Hrvaškem so čigre večinoma letale nad Savo, le izjemoma so se oddaljile tudi več kot 2 km stran od struge. Najdaljša razdalja od gnezdišča je bila več kot 60 km, a tam smo zabeležili zelo majhno število obiskov. Ptice iz kolonije Siromaja 2 so se večinoma zadrževale v radiju do 5 km od gnezdišča, medtem ko so ptice iz kolonije Rakitje redno letale do 23 km oddaljenih območij. Najpogosteje obiskano območje za čigre iz Siromaje in Rakitja je bila Sava pri Hrušćici. Ptice iz kolonije v Rakitju so redno obiskovale tudi Savo pri Savici in nekatere vodne površine v radiju 5 km. To so bila v okolici Zagreba verjetno najpomembnejša območja, na katerih so čigre v času gnezdenja iskale hrano.

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Mitochondrial DNA control region diversity in Common Terns *Sterna hirundo* from Slovenia and Croatia

Raznolikost kontrolne regije mitohondrijske DNK pri navadni čigri *Sterna hirundo* iz Slovenije in Hrvaške

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63 Common Tern *Sterna hirundo* samples from Croatia and Slovenia were analysed with respect to their genetic diversity and differentiation. Samples originated from two freshwater populations (areas of the rivers Sava and Drava) and one coastal population (Sečovlje Salina). The molecular marker of choice was 709 bp long fragment of the mitochondrial control region, the fastest-evolving part of the mitochondrial genome. 21 haplotypes with 12 polymorphic sites were identified. Overall haplotype diversity was substantial and estimated at 0.8599, while the overall nucleotide diversity was low and estimated at 0.0025. Diversity indices were highest for the Drava population, followed by the Sava and the lowest for the Sečovlje population. Overall genetic structure was significantly low (Fst=0.0377) and attributed to the differences in haplotype frequencies between the populations. The high level of genetic diversity found in continental populations illustrates the importance of their habitats as reservoirs of genetic diversity and calls for their further protection and management.

Key words: mtDNA, freshwater colonies, population genetics, Laridae, seabird
Ključne besede: mtDNA, celinske kolonije, populacijska genetika, Laridae, morske ptice

1. Introduction

Common Tern *Sterna hirundo* is a colonial seabird of the family Laridae that breeds both on freshwater and marine habitats of temperate and subarctic regions of Europe, Asia and North America. It is a long-distance migrator, wintering in tropical and subtropical coastal regions. Despite being listed as a species of least concern by the IUCN, the global population trend is mostly unknown on account of variation in trends between different populations (Birdlife International 2018). Freshwater colonies are located mostly on river and lake islands. They are under a strong negative influence of anthropogenic activities, mainly river regulation, as well as under natural threats (e.g. competition with gulls and mammalian predation), which has led to a significant global reduction of the natural freshwater breeding sites. Freshwater populations of the Common Tern are now almost entirely dependent on artificial sites, specifically rafts and gravel islands (Becker & Ludwigs 2004). Freshwater breeding sites in Slovenia and Croatia can be found along the river Sava where the most important breeding site is Rakitje (Martinović *et al.* 2019) and in the river Drava area where the main colony inhabits the Ptuj reservoir. Many small coastal colonies are located along the Adriatic Sea, while one of the largest is located in Sečovlje Salina Nature Park in the Northern Adriatic (Denac *et al.* 2019).

Despite ongoing research, dynamics of both freshwater and coastal populations in Croatia and Slovenia are still relatively unclear. High breeding site fidelity, a well-known characteristic of the Common Tern (Austin 1949) and many other seabird species (Palestis 2014, Coulson 2016), can favour population differentiation by restricting gene flow (Friesen *et al.* 2007). Therefore, population substructuring in long-distance migratory seabirds is seemingly driven by behaviour rather than by physical land barriers (Friesen *et al.* 2007, Szczys *et al.* 2017A).

Genetic studies on wild animal populations are mostly performed using neutral genetic markers such as mitochondrial DNA control region and microsatellites, which are suitable for studies of genetic diversity, genetic structure and demographic processes of populations. Genetic diversity estimation constitutes the basis of many contemporary conservation efforts because it is crucial for the evolutionary potential of species and therefore one of the keys for its long-term survival (Van Dyke 2008). It can thus serve as a measure of the species capacity for future adaptation to environmental challenges.

The control region is the fastest evolving part of the mitochondrial genome, traditionally used as a marker in population genetic and phylogeographic studies. One of the reasons for the ubiquity of the mitochondrial DNA (mtDNA) control region genetic analysis is its exceptionally high polymorphism coupled with conserved arrangement of neighbour genes, which allows for consistent amplification by polymerase chain reaction with many primers. Extreme polymorphism aids in identification of interpopulation as well as intrapopulation lineages. Furthermore, an important property of mtDNA is the uniparental inheritance which results in a lack of recombination. Individual lineages can thus be traced through time in a more straightforward manner than with nuclear markers. Moreover, mtDNA is more sensitive to demographic changes such as bottlenecks and population expansion due to its haploid nature (Freeland *et al.* 2011). Despite downsides to mtDNA analyses (Hurst & Jiggins 2005), mitochondrial DNA has remained the marker of choice in many population and phylogeographic studies.

One of the first population genetic studies of Common Terns was undertaken on populations from North America, using isoelectric focusing of blood proteins. High levels of gene flow were suggested among four colonies as no genetic differentiation was found (Burson III 1990). It was followed by an investigation of Lithuanian colonies using allozymes where some genetic differentiation was reported (Sruoga *et al.* 2002). Further investigations were performed using nuclear genetic markers, specifically microsatellite loci, where significant differentiation among sampled locations was found in Lithuania (Sruoga *et al.* 2006) and in the North Atlantic region (Szczys *et al.* 2012). A later study by Szczys *et al.* (2017B) on cytochrome B revealed hierarchical metapopulation structure with the presence of small- and large-scale connectivity between metapopulations.

To our knowledge, there are no published population genetic studies of Common Tern inferred from an analysis of the mitochondrial DNA control region marker. Thus, in this paper we provide the first assessment of mtDNA control region diversity of Common Terns in general. The goal of this study was to analyse a 709 bp long fragment of the mitochondrial control region in two continental, freshwater populations of Common Terns from Slovenia and Croatia and in a coastal population from Slovenia (Sečovlje Salina). Considering the local and global threats affecting freshwater tern habitats, this study aimed to quantify the levels of genetic diversity in populations of Common Terns from the three geographic areas as well as to detect a possible phylogeographic structure. Furthermore, the intention was to gain insight into possible expansions or bottlenecks in their population history.

2. Methods

We caught 63 Common Terns during their breeding period in the spring and summer of 2017 (6 individuals), 2018 (54 individuals) and 2019 (3 individuals). Sampling took place in gravel pits near the river Sava (30 individuals), the river Drava (22 individuals from Ptuj accumulation and 2 individuals further downstream) and in Sečovlje Salina (9 individuals) (Figure 1). Around 50 µL of blood was taken from the brachial vein and stored either in EDTA coated tubes on ice or on bloodstain storage cards (Nucleocard, Machery Nagel), while feathers were taken from some individuals and kept in paper envelopes at room temperature.

DNA was extracted using DNeasy Blood and Tissue kit (Quiagen, Hilden Germany) following the manufacturer's protocol. To amplify ~800 bp long fragment of the control region, we designed primers SH-mtCR4F (AACACCCATC-CAACTCGGAA) and SH-mtCR4R (AAT-TTCACTGTCGTTGACGTGT) using the mitogenome sequence from GeneBank (Yang *et al.* 2017). PCR conditions were as follows: 3 min denaturation at 95°C, followed by 40 cycles of 30s at 95°C, 45s of annealing at 52°C, and 45s of elongation at 72°C. Final elongation period was 10 min at 72°C. Upon PCR amplification, the samples were sent for purification and sequencing to Macrogen Europe, Amsterdam, the Netherlands. Sequences were aligned, inspected and adjusted to the length of 709 bp using Applied Biosystems SeqScape software. Three samples from the river Sava area were excluded from further analysis as their electropherograms showed unresolved peak duplications.

Mega X (Kumar *et al.* 2018) was used to determine the best nucleotide substitution model according to the Bayesian Information Criterion (BIC). The selected model with the lowest BIC score was Kimura 2-parameter with Gamma distributed rates (Nei & Kimura 2000).Arlequin (Excoffier & Lischer 2010) was used to determine the number of haplotypes (H), assign haplotypes to the individuals, determine the number of variable positions, nucleotide composition, and for calculation of haplotype diversity (Hd) – the probability that two randomly chosen sequences are different. The mean number of pairwise differences and nucleotide diversity (π) – the probability that the two homologous nucleotides differentiate – were calculated with Arlequin as well. AMOVA (Analysis of Molecular Variance) was conducted in order to investigate spatial genetic structuring by analyzing covariance components utilizing information on haplotype frequencies and nucleotide distance between haplotypes (Excoffier *et al.* 1992), as implemented in Arlequin. Population groups were defined as ''Sava'', ''Drava'' and ''Sečovlje''. Pairwise FST and ΦST values for each group were calculated in Arlequin as well. Significance was tested using 10,000 non-parametric permutation procedures.

DnaSp (Rozas *et al.* 2017) was used to calculate Fu's Fs (Fu 1997) and Tajima's D (Tajima 1989) neutrality tests in order to detect past demographic changes. Fu's Fs is based on the deviation of haplotype frequencies in comparison with expectation under population stability, while Tajima's D calculates the difference between Theta estimation from the number of polymorphic sites and the Theta estimation from the average number of pairwise differences. Tajima's D value departs from neutrality to negative values in cases of demographic expansion or purifying selection. The significance of both Fu's Fs and Tajima's D was tested using a coalescent tool with 10,000 replicates.

PopART (Population Analysis with Reticulate Trees) (Leigh & Bryant 2015) was used for calculating and visualizating the median-joining haplotype network. Network methods are generally more fitting than tree algorithms in studies of intraspecific genetic diversity as they allow for the presence of ancestral haplotypes in a sample (Bandelt *et al.* 1999, Zachos *et al.* 2010).

3. Results

Analysis of the 709 bp fragment of mtDNA control region in 60 Common Tern individuals revealed 21 haplotypes (GenBank accession no. MN337406 - MN337426) with 12 segregating sites (Table 1). All of the observed substitutions were transitions, while no deletions or insertions were observed. The most common haplotypes were Stehi01 and Stehi03 found in all groups of samples. Stehi03 was prevalent, being found in 35% of samples (Table 2). Low-frequency haplotypes were numerous as 12 haplotypes were found in only one individual each (six unique haplotypes from the Drava, five from the Sava and one from Sečovlje Salina). Seven haplotypes were shared between samples from the Sava and Drava (Stehi01, Stehi02, Stehi03, Stehi04, Stehi05, Stehi07 and Stehi12), while only two haplotypes (Stehi01 and Stehi03) were shared among all three populations. Haplotypes differed by one to four base substitutions (Figure 2), while mean number of pairwise differences in haplotype sequences of different groups ranged from 0.7044 to 2.1085 (Table 3).

Overall haplotype diversity was estimated at 0.8599, and nucleotide diversity at 0.0025. All diversity indices were highest for the river Drava population. Haplotype diversity for the river Drava was estimated at 0.9239, for the river Sava at 0.8946, while it was the lowest for Sečovlje Salina (0.4167). Nucleotide diversity estimates were found to be in the same order, as well as the mean number of pairwise distances (the highest values for the Drava, followed by the Sava, and the lowest values found in Sečovlje Salina) (Table 3).

Table 1: Segregating sites (S) on the mtDNA control region fragment (709 bp) of *S. hirundo*

Tabela 1: Ločitvena mesta (S) na mtDNA fragmentu kontrolne regije (709 bp) pri navadni čigri

	S1 (5)	S2 (18)	S3 (42)	S4 (75)	S5 (92)	S6 (95)	S7 (98)	S8 (129)	S9 (269)	S10 (282)	S11 (438)	S12 (473)
Stehi01	A	T	C	A	C	C	A	G	G	A	A	C
Stehi02	G	T	C	A	C	T	A	G	G	A	A	C
Stehi03	A	T	C	A	C	T	A	G	G	A	A	C
Stehi04	A	T	C	A	C	C	A	A	G	A	A	C
Stehi05	G	T	C	A	C	C	A	G	G	A	A	C
Stehi06	A	T	C	A	T	T	A	G	G	A	A	C
Stehi07	A	T	C	A	C	T	A	G	G	A	G	C
Stehi08	A	C	C	A	C	T	A	A	G	A	A	C
Stehi09	A	T	C	A	C	C	A	G	A	A	A	C
Stehi10	G	T	C	A	C	T	A	G	G	A	A	T
Stehi11	A	T	C	A	C	T	A	G	G	A	A	T
Stehi12	A	T	C	A	C	T	A	A	G	A	A	C
Stehi13	A	T	C	G	T	T	A	G	G	A	A	C
Stehi14	A	T	C	A	C	C	A	G	G	A	A	C
Stehi15	A	T	T	A	C	T	A	A	G	A	A	C
Stehi16	G	T	C	A	C	T	A	A	G	A	A	C
Stehi17	A	T	C	A	T	C	A	A	G	A	A	C
Stehi18	A	T	C	A	C	T	G	A	G	A	A	C
Stehi19	A	T	C	A	C	T	A	A	G	G	A	C
Stehi20	G	T	C	A	T	T	A	A	G	A	A	C
Stehi21	A	T	T	A	T	T	A	G	G	A	A	C

Table 2: Distribution and frequency (%) of 21 *S. hirundo* mtDNA control region haplotypes

Tabela 2: Razporeditev in frekvenca (%) 21 haplotipov mtDNA kontrolne regije pri navadni čigri

Haplotype haplotip	Sava (N=27)	Drava (N=24)	Sečovlje Salina (N=9)	Total (N=60)
Stehi01	3 (5.00)	2 (3.33)	1 (1.67)	6 (10.00)
Stehi02	3 (5.00)	2 (3.33)	0	4 (6.67)
Stehi03	8 (13.33)	7 (10.00)	6 (11.67)	21 (35.00)
Stehi04	2 (3.33)	1 (1.67)	0	3 (5.00)
Stehi05	1 (1.67)	3 (5.00)	0	4 (6.67)
Stehi06	2 (3.33)	0	0	2 (3.33)
Stehi07	2 (3.33)	1 (1.67)	0	3 (5.00)
Stehi08	1 (1.67)	0	0	1 (1.67)
Stehi09	1 (1.67)	0	0	1 (1.67)
Stehi10	1 (1.67)	0	0	1 (1.67)
Stehi11	1 (1.67)	0	0	1 (1.67)
Stehi12	1 (1.67)	2 (3.33)	0	3 (5.00)
Stehi13	0	1 (1.67)	0	1 (1.67)
Stehi14	0	1 (1.67)	0	1 (1.67)
Stehi15	0	1 (1.67)	0	1 (1.67)
Stehi16	0	1 (1.67)	0	1 (1.67)
Stehi17	0	1 (1.67)	0	1 (1.67)
Stehi18	0	0	1 (1.67)	1 (1.67)
Stehi19	1 (1.67)	0	0	1 (1.67)
Stehi20	0	2 (3.33)	0	1 (1.67)
Stehi21	0	2 (3.33)	0	1 (1.67)

Table 3: Genetic diversity indices and neutrality test results for 709 bp fragment of mtDNA control region in *S. hirundo*. Statistically significant values ($p < 0.02$ for Fs, $p < 0.05$ for D) are marked in bold. N – number of individuals, H – number of haplotypes, Hd – haplotype diversity, π – nucleotide diversity, k – mean number of pairwise differences, S – segregating sites, D – Tajima's D, Fs – Fu's Fs.

Table 3: Indeks genetske raznovrstnosti in test nevtralnosti za 709 bp dolge fragmente mtDNA kontrolne regije pri navadni čigri. Statistično značilne vrednosti ($p < 0.02$ za Fs, $p < 0.05$ za D) so v krepkem tisku. N – število osebkov, H – število haplotipov, Hd –haplotipska raznovrstnost, π – nukleotidska ranovrstnost, k – povprečno število parnih razlik, S – predeli ločevanja, D – Tajima's D, Fs – Fu's Fs.

Population populacija	N	H	Hd	Π	k	S	D	Fs
Sava	27	13	0.8946	0.0025	1.7920	9	-0.8998	**-8.8476**
Drava	24	14	0.9239	0.0030	2.1085	6	0.1367	**-10.2569**
Sečovlje Salina	9	3	0.4167	0.0010	0.7044	3	**-1.5130**	-0.3802
Total	60	21	0.8599	0.0025	1.7721	12	-1.0263	**-17.8652**

Table 4: Pairwise φST (above the diagonal) and FST values (below the diagonal) for the continental groups of *S. hirundo* populations. Statistically significant values ($p < 0.05$) are marked in bold.

Tabela 4: Parne φST (nad diagonalo) in FST vrednosti (pod diagonalo) za populacije navadne čigre. Statistično značilne vrednosti so v krepkem tekstu.

	Sava	Drava	Sečovlje Salina
Sava	-	-0.00561	-0.01439
Drava	-0.01230	-	0.05137
Sečovlje Salina	**0.09631**	**0.11969**	-

At least one neutrality test for each group of samples suggested historical expansion. Large negative and significant values of Fu's Fs were detected in sample sets from the Drava and the Sava and in the overall data set. Tajima's D was significant exclusively in the samples from Sečovlje Salina, where Fu's Fs test was not significant (Table 3).

Haplotypes were dispersed without evident spatial association (Figure 2). Within population measure inferred by AMOVA accounted for 98.81% of variance. Global ΦST based on molecular distance was low (0.0041) and insignificant, as well as pairwise ΦST values. However, global fixation index FST based on F-statistics (haplotype frequencies) was low (0.0377) but significant ($p = 0.0389$), as well as the pairwise FST values that were estimated at 0.09631 and 0.11969 when Sečovlje Salina was compared against the Sava and the Drava respectively (Table 4).

4. Discussion

In this paper we report results of the first assessment of Common Tern mtDNA control region diversity. The sample set consisted of individuals breeding in Slovenia and Croatia, with the majority of samples originating from continental, freshwater colonies.

During the conduction of this study, double electropherogram peaks were noticed in three samples (data not shown), indicating possible

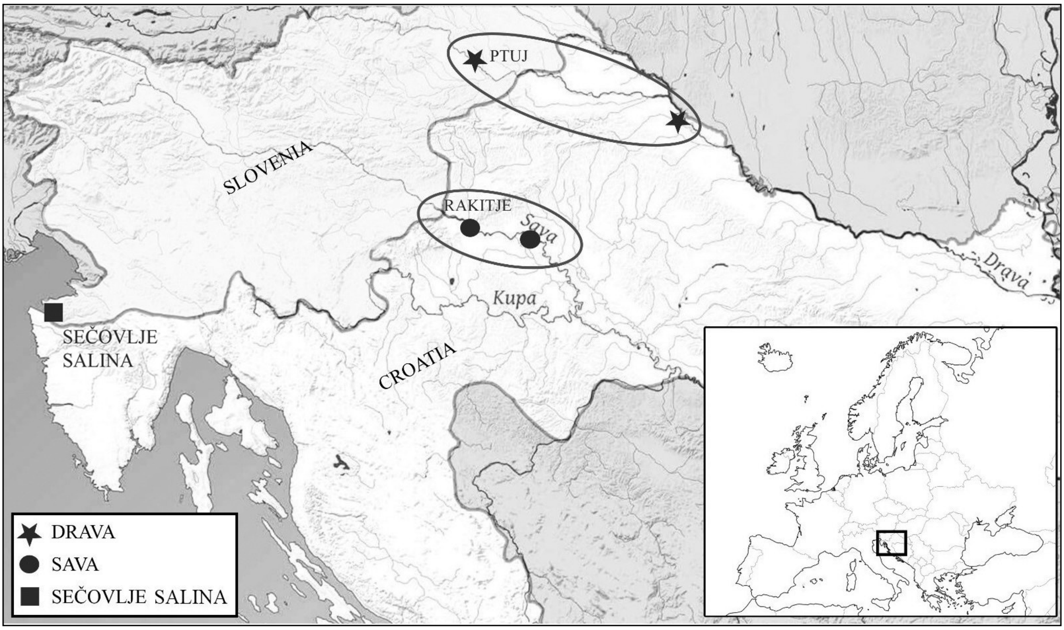

Figure 1: Sampling locations for Common Tern colonies in Croatia and Slovenia

Slika 1: Mesta vzorčenja kolonij navadne čigre na Hrvaškem in v Sloveniji

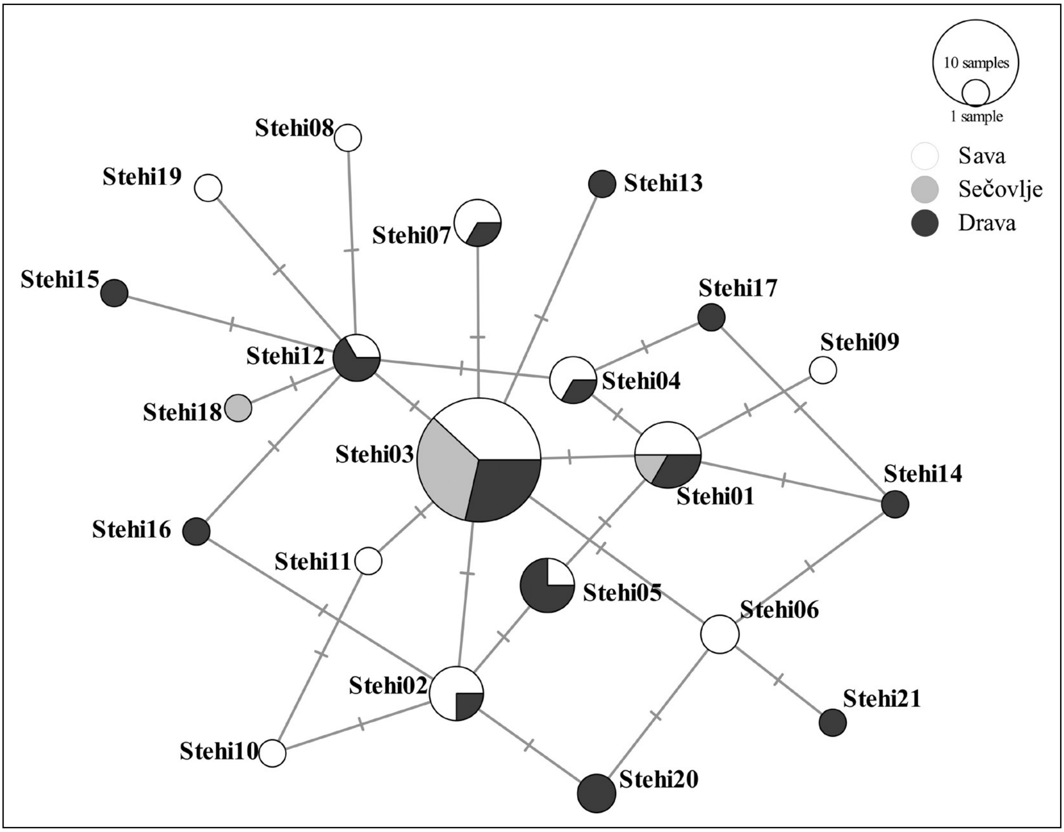

Figure 2: Median-joining haplotype network generated by the program Pop Art based on the mtDNA control region haplotypes of *S. hirundo*. Size of the circles is proportional to the frequency of the haplotype. Different shades represent sample groups Sava, Drava and Sečovlje Salina. The number of hatch marks indicates the number of mutational differences between haplotypes.

Slika 2: Haplotipska mreža mtDNA kontrolnih regij navadne čigre, narejena s programom Pop Art. Velikost kroga je proporcionalna frekvenci haplotipa. Različne sivine ponazarjajo skupine s Save, Drave in iz Sečoveljskih solin. Število oznak ponazarja število mutacijskih razlik med haplotipi.

control region duplication, and therefore those samples were excluded from further analysis. Ambiguities in the control region are regularly reported in seabird species (Friesen *et al.* 2007, Skujina *et al.* 2016) and for that reason, cytochrome B is usually the preferred choice of mitochondrial marker for population genetic studies in Terns (Faria *et al.* 2010, Miller *et al.* 2013, Boutillier *et al.* 2014; Szczys *et al.* 2017a, Szczys *et al.* 2017b). However, the control region is much more variable and is therefore more suitable for studies of genetic diversity at the population level. In our study, possible duplication of the control region occurred in low frequency (4.8%) and thus would have had a minor impact on the results. Further research will enable a more precise estimation of mtDNA control region duplication prevalence in Common Tern populations and should aim to resolve them.

Our analyses of samples of Common Terns from two freshwater habitats – rivers Sava and Drava, and from the coastal colony of Sečovlje Salina, revealed a substantial level of haplotype diversity as a large number of haplotypes was detected, specifically 21. This is particularly notable as only 60 samples were analysed in this study. It is somewhat higher than 18 haplotypes found in 89 individuals of Sooty Tern (*Sterna fuscata*) from Eastern Australia and the Coral Sea (Peck & Congdon 2004), whereas it is comparable to 67 mtDNA control region haplotypes found in 188 individuals of Least Tern *Sternula antillarum* from North America (Draheim *et al.* 2010).

Haplotype diversity value of 0.8599 found in this study is substantially high and comparable to the Hd values found in Least Terns with Hd values ranging from 0.76 to 0.96 (Draheim *et al.* 2010). It is also similar to Hd values of cytochrome B mitochondrial marker found in Gull-billed Terns *Gelochelidon nilotica* (Hd values ranged from 0.843 to 0.908) (Miller *et al.* 2013). Moreover, haplotype diversity found in this study is higher than Hd values of *cytochrome-b* sequence found for Common Tern populations from northeastern United States and southern Canada, which ranged from 0.21 to 0.77 (Szczys *et al.* 2017b) and those reported for Eurasian Black Tern *Chlidonias niger* populations, which ranged from 0.33 to 0.82 (Szczys *et al.* 2017a). Higher Hd values found in this study come as no surprise as they are expected for more variable markers, such as the control region.

In contrast with high haplotype diversity values, nucleotide diversity values are very low, both in the overall sample (0.0025) as well as in the individual groups (0.0010–0.0030) (Table 3). They are lower than Π values previously reported for Least Terns (ranging from 0.0010 to 0.0069) (Draheim *et al.* 2010), but still higher than those reported for Sooty Terns (Peck & Congdon 2004), where the Π values ranged from 0.0007 to 0.0016. Mean number of pairwise differences between sequences was also low, reflecting small number of mutations between different haplotypes.

Samples from the colonies on the rivers Sava and Drava share more haplotypes (seven) than either of those sets shares with samples from Sečovlje Salina (two out of three haplotypes found in Sečovlje Salina are shared among all three groups and the third haplotype is not shared with any other population) (Table 2). One explanation can be insufficient sampling in Sečovlje Salina, as only nine individuals were sampled there. On the other hand, the finding could be explained by potentially higher movements of individuals between freshwater habitats of the Sava and Drava which have more similar ecological conditions than between any freshwater habitat and Sečovlje Salina, as it represents a dissimilar coastal habitat. Geographical distance could also be a reason for the observed pattern; the Sava and Drava are much closer to each other than the coastal colony of Sečovlje Salina and dispersal rates are expected to be higher in adjacent colonies. Similar results were obtained with tests of genetic differentiation, as pairwise FST values were statistically significant only for coastal-freshwater population pairs. Admittedly, genetic differentiation was weak (0.11969 for Sečovlje Salina – Drava and 0.09631 for Sečovlje Salina – Sava) and observed only in measures that utilize solely F–statistic based on haplotype frequencies, namely global and pairwise FST (Table 4). Again, possible differentiation between the coastal colony of Sečovlje Salina and both freshwater colonies could be due to contrasting ecological factors of freshwater and coastal habitats or to small sample size of the Sečovlje Salina population. However, measures dependent on nucleotide distance (global and pairwise ΦST) did not show differentiation between either any pair of population groups, or in the overall data set (Table 4). Very weak population differentiation, or its absence, observed using mitochondrial cytochrome B markers, was previously noted for Common Terns (Szczys *et al.* 2017b) and Black Terns (Szczys *et al.* 2017a), while those studies demonstrated some level of differentiation using nuclear markers. The opposite pattern was also documented, as Miller *et al.* (2013) detected significant genetic structure by mtDNA analysis of Gull-billed Terns, but did not demonstrate differentiation using microsatellites. Since the results might be highly dependent on the choice of marker, further research on nuclear markers such as microsatellites could offer additional insights into population structure. In general, mitochondrial markers reveal female ancestry while nuclear markers reflect biparentally inherited diversity. Moreover, mitochondrial DNA reflects historical processes, while microsatellites are more informative of contemporary population genetics processes. Therefore, the research on Common Terns that breed in Croatia and Slovenia should be expanded to microsatellite analysis which could offer broader insight into the demographic structure and the genetic variability of the populations.

The finding of numerous low frequency and private haplotypes (Table 2) indicates the populations are not homogenous. High haplotype diversity, low nucleotide diversity, and numerous low frequency haplotypes that differ by a small number of mutations can be explained as a signature of population expansion or indication of recent origin (Peck & Congdon 2004; Faria *et al.* 2010). Neutrality tests of Fu's Fs indicate possible population expansion in the overall sample set and individually in the samples from the Sava and Drava areas (Table 3). Fu's Fs test has a great statistical power to detect excess of low frequency alleles expected in the expanding population (Ramos-Onsins & Rozas, 2002). Tajima's D implied possible expansion for the Sečovlje Salina group as well. These findings might reflect expansion from glacial refugia during the last ice age (Oomen *et al* 2011, Szczys 2017 b) and they are consistent with other published data on terns (Peck & Congdon 2004, Faria *et al.* 2010, Szczys *et al.* 2017 a, Szczys *et al.* 2017 b).

Our findings on mtDNA control region diversity indicate that genetic diversity of Common Tern populations from Slovenia and Croatia is substantially high. Samples from the river Drava exhibited the highest values of haplotype and nucleotide diversity, closely followed by samples from the river Sava area, which illustrates the importance of these habitats as reservoirs of genetic diversity and specifically underscores the value of maintaining artificial sites for the long-term conservation of Common Tern populations in freshwater habitats.

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5. Povzetek

Avtorji prispevka so analizirali genetsko raznolikost in diferenciacijo 63 primerkov navadne čigre *Sterna hirundo* iz Slovenije in Hrvaške. Vzorce so pridobili iz dveh sladkovodnih (območji rek Save in Drave) in ene obalne populacije (Sečoveljske soline). Izbrali so 709 baznih parov dolg molekularni marker, fragment mitohondrijske kontrolne regije, ki je del mitohondrijskega genoma, izpostavljen najhitrejšim evolucijskim spremembam. Odkrili so 21 haplotipov z 12 polimorfičnimi mesti. Skupna haplotipska raznolikost je bila visoka (0,8599), medtem ko je bila nukleotidska raznolikost nizka (0,0025). Indeksi diverzitete so bili najvišji pri dravski, nato pri savski in najnižji pri sečoveljski populaciji. Skupna genetska strukturiranost, pripisana razlikam v pogostosti haplotipov med populacijami, je bila nizka (Fst=0,0377) in statistično značilna. Visoka genetska pestrost v celinskih populacijah navadne čigre prikazuje vrednost njihovih habitatov kot rezervoarjev genetske pestrosti in opozarja na pomembnost nadaljnjega ohranjanja in upravljanja takih habitatov.

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Čigre (Sterninae) v zbirki Prirodoslovnega muzeja Slovenije

Terns (Sterninae) in the collection of the Slovenian Museum of Natural History

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The catalogue presents the data on all specimens of terns (Sterninae) that have been inventoried into the ornithological collection of the Slovenian Museum of Natural History (PMS). The catalogue includes data on preserved as well as lost specimens. The data have been collected from all inventory books at hand in the Slovenian Museum of Natural History. By the end of 2019, 66 different specimens of eight tern species have been recorded in the ornithological collection, of which 56 specimens are still preserved. Most specimens were collected in the 1940–1970 period. The largest number of specimens concerns the Black Tern *Chlidonias niger* and Common Tern *Sterna hirundo*. Among the collected terns, the specimens found in Slovenia predominate. Five specimens originate from other countries, specifically Eritrea, Oman, Serbia and Croatia.

Ključne besede: muzejska zbirka, Laridae, inventar, katalog, zbiralci ptic, zgodovina
Key words: museum collection, Laridae, inventory, catalogue, bird collectors, history

1. Uvod

Prirodoslovni muzej Slovenije (PMS) je bil kot Kranjski deželni muzej ustanovljen leta 1821, vendar pa zbirka ptic oziroma vretenčarjev ni bila med znanimi ustanovnimi zbirkami muzeja, čeprav so ornitološke zbirke na Slovenskem nastajale že v drugi polovici 18. stoletja (Vrezec & Berg 2019). Prvo zbirko vretenčarjev je osnoval kustos Henrik Freyer v prvi polovici 19. stoletja (Kryštufek & Jernejc Kodrič 2013). Muzejske zbirke ptic so bile sprva namenjene predvsem taksonomskim raziskavam, danes pa se pomen in vloga muzejskih ornitoloških zbirk spreminjata (Mearns & Mearns 1998, Mlikovsky 2010, Töpfer 2010, Vrezec 2016). Muzejski primerki so namreč zanesljiv vir podatkov o avifavni preteklosti z različnih vidikov (Winker 2004), od avifavnističnih, naravovarstvenih, do povsem okoljevarstvenih, saj je v ohranjenih primerkih iz preteklosti ohranjen tudi odtis okolja, v katerem so te ptice živele (Movalli *et al.* 2017). Zaradi tega je nadaljevanje sistematičnega zbiranja ptic še vedno smiselno in potrebno (Fjeldså & Kristensen 2010), da ohranimo tudi biološko okoljski dokument današnje dobe. Prav zaradi novih trendov uporabe muzejskih naravoslovnih zbirk so objave katalogov in pregledov zbranega in ohranjenega materiala smiselne.

Čiger (Sterninae) za potrebe muzejskih zbirk v Sloveniji niso nikoli zbirali sistematično, pač pa je vedno šlo za bolj ali manj priložnostna dopolnila zbirk. Primerki čiger so v ornitoloških zbirkah na Slovenskem bili poznani že pred nastankom osrednje muzejske zbirke ptic, v kateri najstarejši ohranjeni primerek z znanim datumom datira v leto 1841 (Kačar & Vrezec 2018a). Scopoli (1769) navaja v svojem popisu ptic Kranjske iz 18. stoletja več vrst čiger, v lastni zbirki pa je hranil primerek navadne čigre *Sterna hirundo* z ljubljanskih močvirij *(paludum Labacensium)*, imenovan kot *Larus hirundo*, in še najmanj en primerek z neznane lokacije, imenovan kot *Larus columbinus* (interpretacija Scopolijevih imen je povzeta po Gregori 2008). Primerke čiger je imel v svoji zbirki tudi baron Žiga Zois, in sicer primerek navadne čigre in primerek male čigre *(Sternula albifrons*; imenovana kot *Sterna minuta)*, vendar brez natančnih navedb kraja in datuma najdbe. Oba primerka sta bila sicer najverjetneje zbrana pred letom 1800 (Vrezec & Berg 2019). V popisu kranjskih sesalcev, ptic, plazilcev in rib iz prve polovice 19. stoletja Freyer (1842) navaja pet vrst čiger (Gregori 1992), navadno čigro, malo čigro (kot *Sterna minuta)*, kričavo čigro *(Thalasseus sandvicensis* kot *Sterna cantiaca)*, črno čigro *(Chlidonias niger* kot *Sterna nigra)* in beloperuto čigro *(C. leucopterus* kot *Sterna leucoptera)*, vendar brez navedb kraja in datuma najdbe. Pričujoči katalog čiger (Sterninae) v zbirki Prirodoslovnega muzeja Slovenije (PMS) je prispevek k javni predstavitvi muzejskega materiala v seriji kataloških objav o pticah Kustodiata za vretenčarje (Vrezec & Kačar 2016, 2017, Gregori s sod. 2018). V katalogu so predstavljeni podatki o vseh primerkih čiger, zbranih v okviru dejavnosti PMS. To poleg ohranjenih vključuje tudi propadle ali izgubljene primerke.

2. Podatkovni viri

Ključni vir za pripravo kataloga je bila inventarna knjiga - *Inventarna knjiga ptic Prirodoslovnega muzeja Slovenije, Ljubljana* (PMSL), ki jo vodimo od leta 2015 dalje v muzejskem informacijskem sistemu Galis. Osnova PMSL so inventarne številke iz Študijske inventarne knjige ptic (ŠIKP) s prvimi zapisi v začetku 20. stoletja, ki so jo kustosi dopolnjevali vse do vzpostavitve digitalne baze podatkov leta 2013 (Vrezec & Kačar 2017). V muzeju pa sta se v preteklosti vodili še najmanj dve inventarni knjigi. Najstarejša je stara inventarna knjiga, poimenovana *Inventarna knjiga sesalcev, rib, ptic, plazilcev Prirodoslovnega muzeja* (SIK), in je glavni vir podatkov o razstavni zbirki dermoplastik in skeletov, pridobljenih med letoma 1841 in 1974. Drugi vir podatkov pa je *Katalog zbirke Državnega ornitološkega observatorija* (KDOO), katerega dejavnost je leta 1944 prešla pod pokroviteljstvo PMS (Gregori 2009). V njem so zavedeni preparati, pridobljeni med letoma 1903 in 1964, šlo pa je predvsem za študijsko zbirko, ki je bila, z izjemo

Tabela 1: Pregled števila muzealij vrst čiger (Sterninae) po tipih preparatov v ornitološki zbirki Prirodoslovnega muzeja Slovenije. Številka pomeni število enot, ohranjenih v zbirki, številka v oklepaju pa število vseh zavedenih enot v muzejske knjige, ki vključuje tudi uničene muzealije.

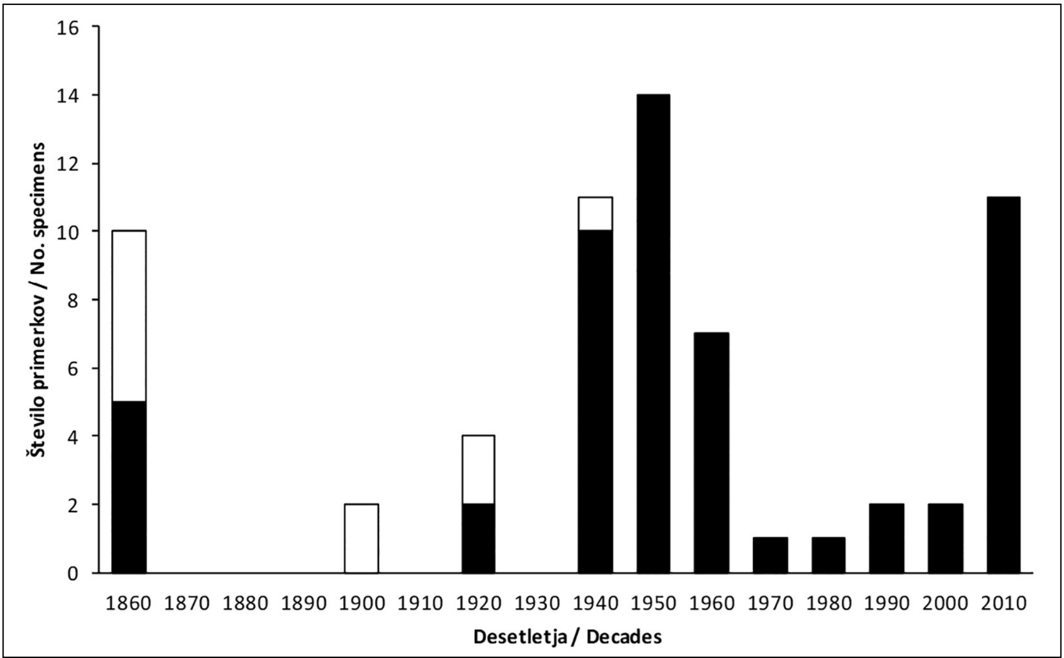
Table 1: An overview of the number of specimens of tern (Sterninae) species by types of preparations in the ornithological collection of the Slovenian Museum of Natural History. The number indicates the number of units preserved in the collection, while the number in brackets designates the number of all recorded units in the museum book, which also includes lost specimens.

Vrsta / Species	Dermo-plastika / Mount	Meh / Skin	Deli / Parts	Peresa / Feathers	Lobanja / Skull	Skelet / Skeleton	Jajca / Eggs	Alkohol / Alcohol	Št. primerkov / No. specimens
Chlidonias hybrida	0 (0)	1 (1)	1 (1)	0 (0)	0 (0)	1 (1)	0 (0)	0 (0)	1 (1)
Chlidonias leucopterus	1 (1)	4 (4)	0 (0)	0 (0)	0 (0)	1 (1)	0 (0)	0 (0)	6 (6)
Chlidonias niger	4 (8)	17 (19)	0 (0)	0 (0)	2 (2)	0 (0)	0 (0)	0 (0)	23 (29)
Hydroprogne caspia	0 (0)	1 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (1)
Sterna hirundo	1 (2)	4 (6)	0 (0)	0 (0)	1 (1)	0 (0)	9 (9)	3 (3)	18 (21)
Sternula albifrons	2 (3)	1 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	3 (4)
Thalasseus bengalensis	0 (0)	0 (0)	0 (0)	0 (0)	2 (2)	1 (1)	0 (0)	0 (0)	2 (2)
Thalasseus sandvicensis	0 (0)	1 (1)	0 (0)	1 (1)	0 (0)	0 (0))	0 (0)	0 (0)	2 (2)
skupaj/total	8 (14)	29 (33)	1 (1)	1 (1)	5 (5)	3 (3)	9 (9)	3 (3)	56 (66)

propadlega materiala, prepisana v ŠIKP. Danes vse muzejske primerke vodimo v enotni inventarni knjigi PMSL (Vrezec & Kačar 2017).

3. Zbirka čiger v Prirodoslovnem muzeju Slovenije

V ornitološko zbirko Prirodoslovnega muzeja Slovenije je bilo doslej zavedenih 66 različnih primerkov osmih vrst čiger, pri čemer so nekateri primerki zastopani z različnimi tipi preparatov (tabela 1). Med tipi preparatov prednjačijo študijski mehovi, osteološka in oološka zbirka pa sta skromni. Do danes se je ohranilo 56 primerkov (85 %), kar je precej več kot na primer pri vpijatih (Coraciiformes) (Vrezec & Kačar 2017). Propadli so le primerki, zbrani do leta 1950, največji del propadlih preparatov pa je bilo zbranih v 19. stoletju (Slika 1). Največ primerkov je bilo zbranih v obdobju 1940–1970, v zadnjem času pa gre število pridobitev na račun primerkov jajc in mrtvih mladičev, zbranih v okviru monitoringa gnezditvenih kolonij. Po številu primerkov zbujata pozornost črna *Chlidonias niger* in navadna čigra *Sterna hirundo*, ki sta po velikosti populacije, ki se pri nas pojavlja tako na selitvi kot v času gnezditve, najštevilnejši. Druge vrste so skromneje zastopane. V zbirki je vsaj z enim primerkom zastopanih osem od desetih vrst čiger, ki so bile doslej opazovane v Sloveniji (Hanžel & Šere 2011, Hanžel 2017). Manjkata črnonoga *Gelochelidon nilotica* in polarna čigra *Sterna paradisea*, bengalska čigra *Thalasseus bengalensis* pa v zbirki ni zastopana s primerki iz Slovenije. V zbirki prevladujejo čigre, pridobljene na ozemlju Slovenije (82 %), pri nadaljnjih 9 % pa izvor ni znan, a po vsej verjetnosti izvirajo iz Slovenije. Zgolj pet primerkov izvira iz tujine, in sicer iz Eritreje (2), Omana (1), Srbije (1) in Hrvaške (1).



Slika 1: Dinamika pridobitev čiger (Sterninae) po desetletnih obdobjih med letoma 1866 in 2019 za ornitološko zbirko Prirodoslovnega muzeja Slovenije glede na zapise v inventarnih knjigah. Črni stolpci prikazujejo primerke, ki so še vedno ohranjeni (N = 55), beli stolpci pa neohranjene primerke (N = 10). Prikazani so le primerki z znano letnico pridobitve.

Figure 1: Dynamics of acquisitions of terns (Sterninae) for the ornithological collection of the Slovenian Museum of Natural History according to ten-year periods between 1866 and 2019 based on the records in inventory books. The black columns indicate still preserved specimens (N = 55), while white columns designate lost specimens (N = 10). Only specimens with known year of accession are shown.

4. Katalog čiger v Prirodoslovnem muzeju Slovenije

V nadaljevanju podajamo kataloški pregled primerkov čiger, ki so ali so bili del ornitološke zbirke Prirodoslovnega muzeja Slovenije. Propadli primerki, ki niso več ohranjeni v zbirki, so označeni z *. Slednji so označeni z inventarno številko knjige, v katero so bili nazadnje vpisani, vsi drugi pa nosijo inventarno številko PMSL. V katalogu so navedeni znani podatki o kraju najdbe s koordinato, tipom preparata (kot je navedeno v Tabeli 2), spolom in starostjo ptice, datumom najdbe, najditeljem (leg.) in preparatorjem (prep.).

Hydroprogne caspia (Pallas, 1770)

Slovenija
Šmartno ob Savi (46°5' N, 14°34' E, 280 m nmv): meh (PMSL 433), ♂, ad., 13. 4. 1950, leg. in prep. Alojz Šmuc (Slika 2)

V Sloveniji je kaspijska čigra redek preletnik na spomladanski in jesenski selitvi (Bordjan & Božič 2009, Bordjan 2012, Škornik 2012). V zbirko PMS je bil pridobljen le en primerek, ki je bil ustreljen leta 1950 v Šmartnem pri Savi (slika 2). Primerek, prepariran kot študijski meh, je bil del zbirke Ornitološkega observatorija v Stožicah.

Thalasseus bengalensis bengalensis (Lesson, 1831)

Eritreja
Sheikh Said (15°59' N, 39°48' E, 4 m nmv): lobanja, skelet (PMSL 4574), 7. 1. 1961, leg. in prep. Savo Brelih
Sheikh Said (15°59' N, 39°48' E, 4 m nmv): lobanja (PMSL 4575), 7. 1. 1961, leg. in prep. Savo Brelih (Slika 3)

Jedro populacije in razširjenosti nominotipske podvrste bengalske čigre je Rdeče morje (del Hoyo *et al.* 1996). V zbirko PMS sta bila pridobljena dva primerka, ki ju je zbral Savo Brelih na odpravi v Etiopijo in Eritrejo med letoma 1960 in 1961 (Brelih 1979). Brelih je zbiral predvsem zunanje zajedavce ptic, ob tem pa s primerki etiopskih ptic obogatil tudi ornitološko zbirko PMS. Večino ptic je prepariral kot mumije, ki pa so kasneje vse propadle (Vrezec & Kačar 2017). Primerka bengalskih čiger sta bila sicer verjetno že sprva ohranjena le kot lobanji in skelet (Slika 3).

Slika 2: Študijski meh kaspijske čigre *Hydroprogne caspia*, ad. ♂, iz Šmartnega ob Savi, ki ga je zbral in prepariral Alojz Šmuc. Primerek PMSL 433, zbran 13. 4. 1950. Foto: David Kunc

Figure 2: A study skin of the Caspian Tern *(Hydroprogne caspia)*, ad. ♂, from Šmartno ob Savi, collected and prepared by Alojz Šmuc. Specimen PMSL 433 was collected on 13 April 1950. Photo: David Kunc

Slika 3: Lobanja bengalske čigre *Thalasseus bengalensis bengalensis* iz Eritreje, ki jo je zbral in prepariral Savo Brelih. Primerek PMSL 4575, zbran 7. 1. 1961 pri kraju Sheikh Said. Foto: David Kunc

Figure 3: A skull of the Lesser Crested Tern *Thalasseus bengalensis bengalensis* from Eritrea, collected and prepared by Savo Brelih. Specimen PMSL 4575 was collected on 7 January 1961 at Sheikh Said. Photo: David Kunc

Thalasseus sandvicensis **(Latham, 1787)**

Slovenija
Portorož (45°31' N, 13°36' E, 64 m nmv): meh (PMSL 1459), ♀, 1Y, 30. 12. 1973, leg. in prep. Alojz Šmuc (Slika 4)

Oman
Dhofar, Slalalah, Khawr Rawri (17°2' N, 54°26' E, 20 m nmv): peresa (PMSL 7176), 15. 10. 2000, leg. Slavko Polak, prep. Al Vrezec

Kričava čigra v Sloveniji redno prezimuje ob morski obali (Sovinc 1994), kljub temu pa je doslej znana le ena najdba mrtve ptice na Obali, in sicer med Simonovim zalivom in Strunjanom dne 5. 3. 1989 (Makovec 1989). Primerek ni bil shranjen. Z območja Obale je leta 1973 za zbirko PMS preparator Alojz Šmuc pridobil tudi edini primerek iz Slovenije (Slika 4). V zbirki PMS trenutno hranimo še nekaj peres kričave čigre iz Omana, ki jih je leta 2000 zbral Slavko Polak, za zbirko pa prepariral Al Vrezec.

Slika 4: Študijski meh kričave čigre *Thalasseus sandvicensis,* 1Y ♀, iz Portoroža, ki ga je zbral in prepariral Alojz Šmuc. Primerek PMSL 1459, zbran 30. 12. 1973. Foto: David Kunc

Figure 4: A study skin of the Sandwich Tern *Thalasseus sandvicensis,* 1Y ♀, from Portorož, collected and prepared by Alojz Šmuc. Specimen PMSL 1459 was collected on 30 December 1973. Photo: David Kunc

Sternula albifrons albifrons (Pallas, 1764)

<u>Slovenija</u>
Ljubljana, Stožice (46°5' N, 14°31' E, 293 m nmv): meh (PMSL 1015), ♀, juv., 5. 8. 1950, leg. in prep. Alojz Šmuc (Slika 6)

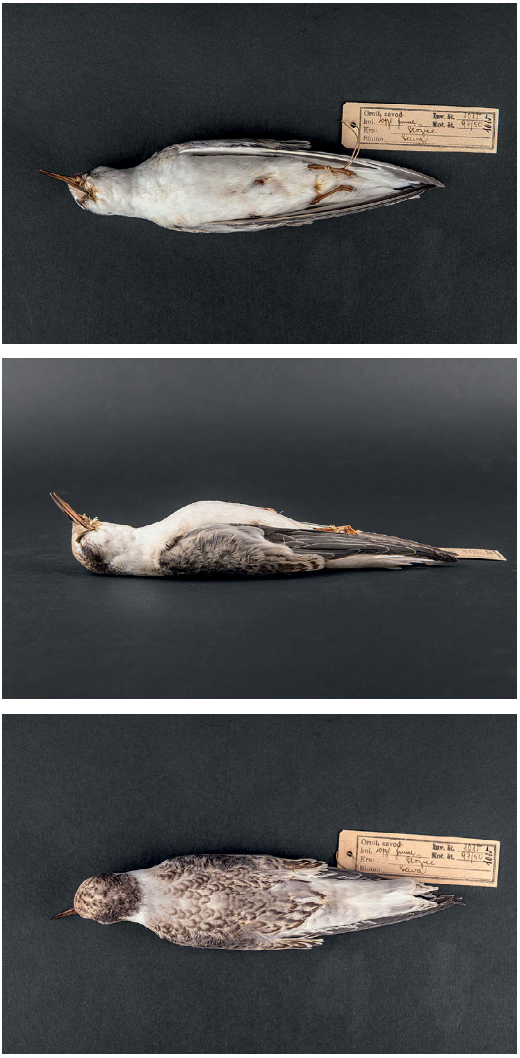
<u>Neznana lokaliteta</u>
dermoplastika (PMSL5238), 1Y, [1868]
dermoplastika (PMSL5416), ♂, ad., [1868] (Slika 5)
*dermoplastika (SIK 711), [1868]

Mala čigra sodi med občasno ugotovljene gnezdilke (Vrezec 2019). V zadnjih 50 letih je redno gnezdila le v Sečoveljskih solinah, gnezdenje v celinskem delu Slovenije pa je bilo občasno, maloštevilno in lokalno (Geister 1995, Škornik 2019). V zbirki PMS je ohranjenih več primerkov, z ohranjenimi podatki pa le eden. Slednji je zanimiv kot verjetni gnezditveni podatek s savskih prodišč v Stožicah

Slika 5: Dermoplastika male čigre *Sternula albifrons,* ad. ♂. Primerek PMSL 5416, zbran pred letom 1868. Foto: Ciril Mlinar Cic

Figure 5: Mount of the Little Tern *Sternula albifrons,* ad. ♂. Specimen PMSL 5416 was collected before 1868. Photo: Ciril Mlinar Cic

pri Ljubljani iz leta 1950, saj gre za juvenilno ptico, ustreljeno v avgustu (Slika 6; Kačar & Vrezec 2018b). Gre za edini znani dokument o verjetnem obstoju savskega gnezdišča, ki ga že v 70-ih letih 20. stoletja ni bilo več (Šere 1982). Drugi primerki so bili pridobljeni pred letom 1868 in so bili del stare razstavne zbirke muzeja. Ohranjena sta le še dva od treh primerkov (Slika 5), ni pa jasno, ali gre za primerke Ferdinanda Schulza, Henrika Freyerja ali morda še za starejše primerke. Malo čigro namreč v svojih popisih omenjata tako Freyer (1842) kot Zois (Vrezec & Berg 2019). Kljub znanim gnezditvenim kolonijam v Sloveniji v zbirki PMS ni ohranjenih jajc ali jajčnih lupin male čigre.



Slika 6: Študijski meh male čigre *Sternula albifrons*, juv. ♀, iz Stožic pri Ljubljani, ki ga je zbral in prepariral Alojz Šmuc. Primerek PMSL 1015, zbran 5. 8. 1950. Foto: David Kunc

Figure 6: A study skin of the Little Tern *Sternula albifrons*, juv. ♀, from Stožice near Ljubljana, collected and prepared by Alojz Šmuc. Specimen PMSL 1015 was collected on 5 August 1950. Photo: David Kunc

Sterna hirundo hirundo **Linnaeus, 1758**

Slovenija

Koper, Škocjanski zatok (45°33' N, 13°45' E, 0 m nmv): mokri preparat (PMSL 5458), pull., 29. 5. 2013, leg. Igor Brajnik, prep. Urška Kačar (Slika 9)

Koper, Škocjanski zatok (45°33' N, 13°45' E, 0 m nmv): mokri preparat (PMSL 5459), pull., 29. 5. 2013, leg. Igor Brajnik, prep. Urška Kačar (Slika 9)

Koper, Škocjanski zatok (45°33' N, 13°45' E, 0 m nmv): mokri preparat (PMSL 5487), ♂, pull., 29. 5. 2013, leg. Igor Brajnik, prep. Al Vrezec (Slika 9)

Koper, Škocjanski zatok (45°33' N, 13°45' E, 0 m nmv): jajce (PMSL 5230), 29. 5. 2013, leg. Igor Brajnik, prep. Dare Fekonja

Ljubljana, Ljubljanica pred Zalogom (46°4' N, 14°37' E, 269 m nmv): meh (PMSL 200), ♂, ad., 5. 8. 1923, leg. dr. Janko Ponebšek

Ptuj, Podvinci (46°26' N, 15°55' E, 224 m nmv): meh (PMSL 572), ♀, ad., 31. 7. 1954, leg. Božidar Ponebšek, prep. Janez Dovič

Ptuj, Spodnji Šturmovci (46°23' N, 15°54' E, 215 m nmv): meh (PMSL 571), ♀, ad., 1. 8. 1954, leg. Božidar Ponebšek, prep. Janez Dovič

Ptuj, Ptujsko jezero (46°24' N, 15°55' E, 213 m nmv): jajce (PMSL 7497), 23. 5. 2018, leg. Luka Božič, Tilen Basle, Davorin Tome, prep. Dare Fekonja

Ptuj, Ptujsko jezero (46°24' N, 15°53' E, 220 m nmv): jajce (PMSL 7793), 3. 6. 2019, leg. Davorin Tome, prep. Dare Fekonja

Ptuj, Ptujsko jezero (46°24' N, 15°53' E, 220 m nmv): jajce (PMSL 7794), 3. 6. 2019, leg. Davorin Tome, prep. Dare Fekonja

Ptuj, Ptujsko jezero (46°24' N, 15°53' E, 220 m nmv): jajce (PMSL 7795), 3. 6. 2019, leg.

Davorin Tome, prep. Dare Fekonja
Ptuj, Ptujsko jezero (46°24' N, 15°53' E, 220 m nmv): jajce (PMSL 7796), 3. 6. 2019, leg. Davorin Tome, prep. Dare Fekonja
Ptuj, Ptujsko jezero (46°24' N, 15°53' E, 220 m nmv): jajce (PMSL 7797), 3. 6. 2019, leg. Davorin Tome, prep. Dare Fekonja
Sečoveljske soline (45°29' N, 13°36' E, 0 m nmv): jajce (PMSL 3927), 1991
Sečoveljske soline, izliv Dragonje (45°29' N, 13°36' E, 0 m nmv): jajce (PMSL 6739), 1987, leg. in prep. Tomi Trilar (Slika 8)
*Ježica ob Savi (46°6' N, 14°31' E, 292 m nmv): dermoplastika (SIK 1783), 27. 4. 1949, ♀, leg. Božidar Ponebšek, prep. Franc Barbič
*Ljubljanica (46°1' N, 14°30' E, 289 m nmv): meh (KDOO 1410), 5. 8. 1923, ♂, leg. dr. Janko Ponebšek

Hrvaška
Poreč, otok Žontuja (45°12' N, 13°35' E, 0 m nmv): meh (PMSL 3385), pull., 14. 6. 1998, leg. Jože Dolinšek, prep. Vili Žgavec

Srbija
Deliblatska peščara, Labudovo okno (44°51' N, 21°18' E, 67 m nmv): lobanja (PMSL 5448), 4. 5. 2014, leg. in prep. Georg Džukić

Neznana lokaliteta
dermoplastika (PMSL 4945), ad., [1868] (Slika 7)
*meh (SIK 1648), ♀, 15. 9. 1903

Navadna čigra je redna gnezdilka Slovenije tako v celinskem kot obalnem delu države (Denac s sod. 2019). Trenutno znane kolonije so v Sečoveljskih solinah, Škocjanskem zatoku, ob spodnji Savi in ob reki Dravi, morda pa je bila nekdaj njena razširjenost večja po rečnih prodiščih, kjer danes ne gnezdi več. V zbirki PMS je navadna čigra zastopana tako s primerki iz Slovenije kot iz drugih območjih v JV Evropi (Hrvaška, Srbija). Najstarejši ohranjeni primerek je dermoplastika odraslega osebka, ki je bil pridobljen pred letom 1868, vendar natančna provenienca ni znana, čeprav zelo verjetno izvira iz Slovenije (Slika 7). Med starejšimi primerki zbujajo pozornost ptice, zbrane ob Savi pri Ljubljani v spomladanskem in poletnem času, ko je vrsta na savskih prodiščih morda celo gnezdila, saj je bila vrsta v

Slika 7: Dermoplastika navadne čigre *Sterna hirundo,* ad. Primerek PMSL 4945, zbran pred letom 1868. Foto: Ciril Mlinar Cic

Figure 7: Mount of the Common Tern *Sterna hirundo,* ad. Specimen PMSL 4945 was collected before 1868. Photo: Ciril Mlinar Cic

Sloveniji znana gnezdilka rečnih prodišč (Reiser 1925, Ponebšek & Ponebšek 1934). V zbirki PMS so shranjena jajca navadnih čiger, zbrana v kolonijah v Sečoveljskih solinah, Škocjanskem zatoku in na Ptujskem jezeru v recentnem obdobju (Slika 8).

Slika 8: Jajce navadne čigre *Sterna hirundo* iz Sečoveljskih solin, ki ga je zbral in prepariral Tomi Trilar. Primerek PMSL 6739, zbran leta 1987. Foto: David Kunc

Figure 8: Egg of the Common Tern *Sterna hirundo* from Sečoveljske soline, collected and prepared by Tomi Trilar. Specimen PMSL 6739 was collected in 1987. Photo: David Kunc

Slika 9: Mokri preparat treh primerkov navadne čigre *Sterna hirundo,* pull., iz Škocjanskega zatoka, ki jih je zbral Igor Brajnik ter preparirala Urška Kačar in Al Vrezec. Primerki PMSL 5458, PMSL 5459 in PMSL 5487, zbrani 29. 5. 2013. Foto: David Kunc

Figure 9: Wet specimens of the Common Tern *Sterna hirundo,* pull., from Škocjanski zatok, collected by Igor Brajnik and prepared by Urška Kačar and Al Vrezec. Specimens PMSL 5458, PMSL 5459 and PMSL 5487 were collected on 29 May 2013. Photo: David Kunc

Iz kolonije v Škocjanskem zatoku je v alkoholu shranjenih tudi nekaj nedoraslih mladičev (slika 9). Vsa jajca in mladiči so bili zbrani s pasivnim zbiranjem, torej zbiranjem najdenih propadlih jajc ali mrtvih mladičev. V prihodnosti bi bilo smiselno v muzejski zbirki PMS shraniti večjo serijo jajc in mladičev iz propadlih gnezd navadne čigre, kakor tudi kostni material iz znanih slovenskih kolonij, ki se jih lahko zbere ob rednem obročkanju mladičev (Vrezec & Fekonja 2018). Trenutna velikost zbirke namreč še ne omogoča resnih populacijskih študij na materialu navadne čigre iz Slovenije.

Chlidonias hybrida hybrida (Pallas, 1811)

Slovenija

Koper, Škocjanski zatok (45°33' N, 13°45' E, 0 m nmv): meh, perut, skelet (PMSL 5443), ♀, ad., 1. 8. 2007, prep. Al Vrezec (Slika 10)

Belolična čigra se v Sloveniji redno pojavlja na selitvi, čeprav nikjer ni zelo številna (Bordjan & Božič 2009, Bordjan 2012, Škornik 2012). V zbirki PMS je shranjen le en primerek odrasle ptice, ki je bila leta 2007 najdena mrtva v Škocjanskem zatoku (Slika 10). Ptica je ohranjena kot študijski meh, a s shranjenimi ostanki skeleta. Starejših primerkov iz Slovenije ni zavedenih in sodeč po starejši literaturi vrsta pri nas v preteklosti ni bila poznana (Scopoli

Slika 10: Študijski meh in perut belolične čigre *Chlidonias hybrida,* ad. ♀, iz Škocjanskega zatoka, ki ju je prepariral Al Vrezec. Primerek PMSL 5443, zbran 1. 8. 2007. Foto: David Kunc

Figure 10: A study skin and wing of the Whiskered Tern *Chlidonias hybrida,* ad. ♀, from Škocjanski zatok, prepared by Al Vrezec. Specimen PMSL 5443 was collected on 1 August 2007. Photo: David Kunc

1769, Freyer 1842, Schulz 1895, Reiser 1925, Matvejev & Vasić 1973).

Chlidonias leucopterus **(Temminck, 1815)**

Slovenija

Ljubljana, Stožice (46°5' N, 14°31' E, 293 m nmv): meh (PMSL 902), ♂, ad., 7. 5. 1949, leg. in prep. Alojz Šmuc

Ljubljana, Stožice (46°5' N, 14°31' E, 293 m nmv): meh (PMSL 903), ♀, ad., 5. 6. 1950, leg. in prep. Alojz Šmuc

Ljubljana, Stožice (46°5' N, 14°31' E, 293 m nmv): meh (PMSL 904), ♂, ad., 8. 5. 1953, leg. Leopold Breskvar, prep. Janez Dovič (Slika 12)

Ljubljana, Tomačevo (46°5' N, 14°32' E, 289 m nmv): meh (PMSL 905), ♀, ad., 2. 6. 1950, leg. in prep. Alojz Šmuc

Zbiljsko jezero (46°9' N, 14°24' E, 351 m nmv): skelet (PMSL 4345), ♀, 5. 5. 1965

Neznana lokaliteta

dermoplastika (PMSL 5417), ad., [1868] (Slika 11)

Beloperuta čigra sodi med dvomljive slovenske gnezdilke, saj je bila kot taka v preglednih seznamih gnezdilk navedena, nikoli pa gnezditev tako ali drugače ni bila dokazana (Vrezec 2019). Vrsta se pri nas sicer redno pojavlja na selitvi (Bordjan & Božič 2009, Bordjan 2012, Škornik 2012). Večina primerkov v zbirki PMS je bila zbrana med

Slika 11: Dermoplastika beloperute čigre *Chlidonias leucopterus,* ad. Primerek PMSL 5417, zbran pred letom 1868. Foto: Ciril Mlinar Cic

Figure 11: Mount of the White-winged Tern *Chlidonias leucopterus,* ad. Specimen PMSL 5417 was collected before 1868. Photo: Ciril Mlinar Cic

Slika 12: Študijski meh beloperute čigre *Chlidonias leucopterus,* ad. ♂, iz Stožic pri Ljubljani, ki ga je nabral Leopold Breskvar in prepariral Janez Dovič. Primerek PMSL 904, zbran 8. 5. 1953. Foto: David Kunc

Figure 12: A study skin of the White-winged Tern *Chlidonias leucopterus,* ad. ♂, from Stožice near Ljubljana, collected by Leopold Breskvar and prepared by Janez Dovič. Specimen PMSL 904 was collected on 8 May 1953. Photo: David Kunc

letoma 1949 in 1965, večino pa je zbral muzejski preparator Alojz Šmuc. Primerki izvirajo tako iz selitvenega kot gnezditvenega obdobja (junij) in slednji so bili morda tudi v preteklosti razlog, da so beloperuto čigro uvrščali med možne gnezdilke (Slika 12). V zbirki PMS je še vedno ohranjena dermoplastika, ki je bila zbrana pred letom 1868 (Slika 11). Gre po vsej verjetnosti za preparat iz Freyerjeve zbirke (Freyer 1842), saj Schulz (1895) beloperute čigre ne omenja.

Chlidonias niger niger **(Linnaeus, 1758)**

Slovenija
Cerknica (45°48' N, 14°22' E, 568 m nmv): meh (PMSL 201), ♀, 2Y, 29. 3. 1923, leg. A. Werli
Ljubljana, Tomačevo (46°5' N, 14°32' E, 289 m nmv): meh (PMSL 906), ♂, 1Y, 7. 9. 1948, leg. in prep. Alojz Šmuc
Ljubljana, Tomačevo (46°5' N, 14°32' E, 289 m nmv): meh (PMSL 907), ♀, 1Y, 7. 9. 1948, leg. in prep. Alojz Šmuc
Ljubljana, Tomačevo (46°5' N, 14°32' E, 289 m nmv): meh (PMSL 915), ♀, 1Y, 7. 9. 1948, leg. in prep. Alojz Šmuc
Ljubljana, Stožice (46°5' N, 14°31' E, 293 m nmv): meh (PMSL 908), ♂, ad., 9. 5. 1950, leg. in prep. Alojz Šmuc
Ljubljana, Stožice (46°5' N, 14°31' E, 293 m nmv): meh (PMSL 909), ♀, 2Y, 22. 8. 1949, leg. in prep. Alojz Šmuc
Ljubljana, Stožice (46°5' N, 14°31' E, 293 m nmv): meh (PMSL 910), ♀, 2Y, 3. 8. 1950, leg. in prep. Alojz Šmuc
Ljubljana, Stožice (46°5' N, 14°31' E, 293 m nmv): meh (PMSL 911), ♀, juv., 7. 8. 1950, leg. in prep. Alojz Šmuc
Ljubljana, Stožice (46°5' N, 14°31' E, 293 m nmv): meh (PMSL 912), ♀, ad., 26. 5. 1949, leg. in prep. Alojz Šmuc
Ljubljana, Stožice (46°5' N, 14°31' E, 293 m nmv): meh (PMSL 913), ♂, ad., 7. 5. 1949, leg. in prep. Alojz Šmuc
Ljubljana, Stožice (46°5' N, 14°31' E, 293 m nmv): meh (PMSL 914), ♀, ad., 5. 8. 1949, leg. in prep. Alojz Šmuc
Medvode, Verje (46°9' N, 14°25' E, 337 m nmv): lobanja (PMSL 4658), juv., 25. 9. 1953, leg. Franc Barbič ml., prep. Savo Brelih
Medvode, Verje (46°9' N, 14°25' E, 337 m nmv): lobanja (PMSL 4659), ♀, juv., 22. 9. 1953, leg. Franc Barbič ml., prep. Savo Brelih
Piranske soline, Lerra (45°29' N, 13°36' E, 0 m nmv): meh (PMSL 15), ♀, ad., 20. 8. 1960, leg. M. Skergot, prep. Božidar Ponebšek
Piranske soline, Lerra (45°29' N, 13°36' E, 0 m nmv): meh (PMSL 4904), ♂, ad., 20. 8. 1960, leg. M. Skergot, prep. Božidar Ponebšek
Piranske soline (45°29' N, 13°36' E, 0 m nmv): meh (PMSL 4901), ♂, ad., 24. 8. 1960, leg. in prep. Božidar Ponebšek
Podkoren (46°30' N, 13°46' E, 864 m nmv): meh (PMSL 1393), ♂, 1Y, 20. 8. 1966, leg. in prep. Janez Gregori (Slika 14)
Šmartno ob Savi (46°5' N, 14°36' E, 280 m nmv): meh (PMSL 916), ♂, ad., 26. 4. 1949, leg. in prep. Alojz Šmuc
Šmartno ob Savi (46°5' N, 14°36' E, 280 m nmv): meh (PMSL 917), ♂, ad., 26. 4. 1949, leg. in prep. Alojz Šmuc
Zbiljsko jezero (46°9' N, 14°25' E, 351 m nmv): dermoplastika (PMSL 4975), ♀, 1Y, 22. 9. 1953, leg. in prep. Franc Barbič (Slika 13)
Zbiljsko jezero (46°9' N, 14°24' E, 351 m nmv): dermoplastika (PMSL 5947), ♂, 30. 9. 1956, leg. Franc Barbič
*Idrija (45°60' N, 14°2' E, 343 m nmv): dermoplastika (SIK 716), marec 1866
*Cerknica (45°48' N, 14°22' E, 568 m nmv): meh (KDOO 1186), ♀, 29. 3. 1923, leg. A. Werli

[Slovenija]
neznana lokaliteta: dermoplastika (PMSL 7747): iz šolske zbirke Prve gimnazije Maribor

Neznana lokaliteta
dermoplastika (PMSL 4946), 1Y, [1868]
*dermoplastika (SIK 713), ♂, [1868]
*dermoplastika (SIK 714), [1868]
*dermoplastika (SIK 717), ♀, [1866)
*meh (KDOO 1187), ♀, 15. 9. 1903

Črna čigra sodi med izumrle gnezdilke Slovenije (Vrezec 2019), danes pa se redno pojavlja v obdobju selitve, tudi v večjih številih (Bordjan & Božič 2009, Bordjan 2012, Škornik 2012). Zadnja sumljiva gnezdišča so bila ugotovljena v Sečoveljskih solinah, na Cerkniškem jezeru in ob reki Dravi (Geister 1995). V zbirki PMS je črna čigra najbolj zastopana vrsta med čigrami, saj sestavlja skoraj polovico (47 %) vseh primerkov čiger v zbirki. Primerki so bili večinoma zbrani v času spomladanske in jesenske selitve (Sliki 13 & 14), velika večina primerkov pa je bila zbrana med letoma 1948 in 1966 v sklopu aktivnosti Ornitološkega observatorija. Po letu 1966 zbirki ni bila dodana nobena črna čigra več z izjemo starejše dermoplastike (PMSL7747) brez podatkov, ki jo je muzej leta 2017 pridobil s prevzemom šolske zbirke Prve gimnazije Maribor. Čeprav je bilo prvotno v muzejski zbirki kar pet primerkov iz 19. stoletja, se je do danes ohranil le eden, ki je bil pridobljen pred letom 1868. Zelo verjetno gre za primerek iz Freyerjeve zbirke (Freyer 1842), saj Schulz (1895) navaja le primerek, ustreljen dne 2. 9. 1890, ki pa v muzejskih inventarnih knjigah ni bil zabeležen.

5. Zaključek

Ornitološka zbirka Prirodoslovnega muzeja Slovenije je največja in najbolj popolna zbirka ornitološko relevantnega materiala iz Slovenije, ne le pri nas, pač pa tudi po svetu. Zbirke drugih muzejev namreč hranijo malo primerkov ptic iz Slovenije, zato se moramo pri zagotavljanju tovrstnega materiala zanašati na domače vire. Čigre niso bile nikoli predmet sistematične zbiralne politike Prirodoslovnega muzeja Slovenije, zato je razumljivo tovrstna zbirka majhna. Kljub temu pa bi bilo treba

Slika 13: Dermoplastika črne čigre *Chlidonias niger,* 1Y ♀, z Zbiljskega jezera, ki jo je zbral in prepariral Franc Barbič. Primerek PMSL 4975, zbran 22. 9. 1953. Foto: Ciril Mlinar Cic

Figure 13: Mount of the Black Tern *Chlidonias leucopterus,* 1Y ♀, from Zbiljsko jezero, collected and prepared by Franc Barbič. Specimen PMSL 4975 was collected 22.9.1953. Photo: Ciril Mlinar Cic

Slika 14: Študijski meh črne čigre *Chlidonias niger,* 1Y ♂, iz Podkorena, ki jo je zbral in prepariral Janez Gregori. Primerek PMSL 1393, zbran 20. 8. 1966. Foto: Ciril Mlinar Cic

Figure 14: Study skin of the Black Tern *Chlidonias leucopterus,* 1Y ♂, from Podkoren, collected and prepared by Janez Gregori. Specimen PMSL 1393 was collected 20.8.1966. Photo: Ciril Mlinar Cic

za potrebe današnjih in prihodnjih raziskav zbirko čiger bistveno povečati. Današnja zbiralna politika muzeja je v Sloveniji usmerjena zgolj v pasivno zbiranje, kar možnost dotoka novega materiala bistveno spremeni. V obdobju 2000–2019 je bilo v muzej sprejetih 2120 primerkov ptic iz Slovenije. Med njimi je bilo zgolj 16 čiger, ena belolična in 15 navadnih čiger, pri slednjih izključno propadla jajca ter poginuli mladiči, najdeni v kolonijah. Mrtve dorasle primerke čiger je namreč na terenu izjemno težko najti. Zadnji primerek dorasle čigre je bila odrasla ptica belolične čigre leta 2007 iz Škocjanskega zatoka. Ključni vir za dopolnjevanje zbirke čiger so zato kolonije, kjer naravno propade veliko jajc in mladičev, ti pa so dober vir muzejskih študijskih eksponatov. Za ureditev ustrezno velike in raziskovalno (in varstveno) relevantne zbirke bi bilo zato treba stimulirati zbiranje propadlih jajc in mrtvih mladičev čiger ob kontrolnih obiskih kolonij, kar je zlasti relevantno za primerke navadnih in malih čiger. Kljub vsemu obstoječi ohranjeni primerki čiger v zbirki Prirodoslovnega muzeja Slovenije, ki pokrivajo obdobje zadnjih 150 let, še vedno ponujajo dovolj zgodovinskih, avifavnističnih in tudi ekoloških raziskovalnih izzivov, ki jih je mogoče oblikovati na podlagi podatkov, predstavljenih v pričujočem katalogu.

6. Povzetek

V katalogu so predstavljeni podatki o vseh primerkih čiger (Sterninae), ki so bili inventarizirani v ornitološko zbirko Prirodoslovnega muzeja Slovenije (PMS). Vključeni so podatki o ohranjenih primerkih, kot tudi podatki o propadlih ali izgubljenih preparatih. Podatki so zbrani predvsem iz Študijske inventarne knjige ptic, kot tudi iz stare inventarne knjige, poimenovane kot *Inventarna knjiga sesalcev, rib, ptic, plazilcev Prirodoslovnega muzeja* in iz *Kataloga zbirke Državnega ornitološkega observatorija*. Danes so vsi podatki o ohranjenih primerkih zbrani v inventarni knjigi muzejskega informacijskega sistema Galis. Do konca leta 2019 je bilo v ornitološki zbirki evidentiranih 66 različnih primerkov osmih vrst čiger, od tega se je ohranilo 56 primerkov. Največ primerkov je bilo zbranih v obdobju 1940–1970. Večino zbranih primerkov sestavljajo črne *(Chlidonias niger)* in navadne čigre *(Sterna hirundo)*. Med zbranimi čigrami prevladujejo primerki, najdeni v Sloveniji. Pet primerkov izvira iz drugih držav, in sicer Eritreje, Omana, Srbije in Hrvaške.

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Morphometry of inland Common Terns *Sterna hirundo* in Croatia and Slovenia

Morfometrija navadnih čiger *Sterna hirundo* s celinskega dela Hrvaške in Slovenije

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Abstract

Morphometric data on Common Terns breeding in Croatia and Slovenia are presented herewith for the first time. 130 breeding adult Common Terns *Sterna hirundo* were measured between 2016 and 2019 along the Sava and Drava Rivers. Sex was determined for 53 birds: 22 males and 31 females. Significant sexual differences were found for head and bill length, length of bill to skull, and bill depth. Croatian and Slovenian terns had slightly shorter wings and tails compared to birds from the Netherlands, Germany and England and were lighter than birds from Germany and Italy. Head, bill and tarsus lengths were similar to those in north European populations. Contrary to results from Scotland, in our studied population, birds with head and bill lengths >79.0 mm could not be sexed as males reliably.

1. Introduction

Morphometric measures are routinely recorded during bird handling and ringing, resulting in sets of biometric data of different populations. Although researcher's variation in the quality of measurements exists (Morgan 2004), standardised methodology (such as Svensson 1992, Baker 1993, Eck *et al.* 2011) allows the use of these data for morphometric analyses. Many bird species are monomorphic in their plumage, but show some size differences between sexes (Hernández *et al.* 2011). Furthermore, biometric differences recorded between bird populations of the same species found in different geographical areas enabled the identification of subspecies (Svensson 1992). Characterisation of the morphology of individual birds or populations helps to answer questions related to the aerodynamics of flight, responses to environmental changes etc. (Zink & Remsen 1986, Rayner 1995).

Common Tern *Sterna hirundo* is a colonial species that breeds in Europe, Asia and North America, while it winters along sea coasts of the Southern Hemisphere. It inhabits coastal and inland habitats, nesting mostly on beaches and dunes or on rocky or gravel islands (Becker & Ludwigs 2004). In Croatia and Slovenia, the Common Tern breeds both along the coast and inland. The inland population breeds along the Sava and Drava Rivers, mostly on artificial islands of reservoirs and in gravel pits. Common Terns do not have sexual dimorphism in plumage, but females tend to be slightly smaller than males (Becker & Ludwigs 2004). A difference between sexes in head and bill lengths was reported; however, it does not allow determining sex of all birds (Coulter 1986, Craik 1999). The aim of this study was to investigate body measures and sexual differences in adult birds belonging to inland tern populations along the Sava and Drava Rivers in Croatia and Slovenia.

2. Methods

Between 2016 and 2018, we captured 130 breeding adult Common Terns, mostly using walk-in traps on the nest during the incubation stage (19^{th} May to 18^{th} July). Four birds were captured during the later phase of the breeding season with mist nets on a roosting site close to the colony. Along the Sava, 108 birds were captured in the surroundings of Zagreb, Croatia: 74 at Rakitje, 11 at Blato and 23 at a breeding platform on Siromaja gravel pit. Along the Drava, 22 terns were captured on artificial islands at Lake Ptuj, Slovenia.

All birds were measured, fitted with plastic and steel rings and released at the same site. Morphometric measures taken include wing length (maximum length), tarsus length, length of head and bill, length of bill to skull and body mass (Eck *et al.* 2011). In 2017 tail and fork lengths (distance between the shortest and the longest tail feathers) were measured for 41 birds, but this was later omitted, as towards the end of the breeding period many birds have worn tail feathers. Bill depths and widths at distal edge of nostrils (Demongin 2016) were measured for 44 birds captured in 2018 and 2019. Wing and tail lengths were measured using a stopped ruler with 1 mm precision, while head and bill lengths, lengths of bill to skull, bill depths and widths and tarsus lengths were measured by callipers with 0.1 mm precision. Body mass was obtained using a digital scale with 0.5 g precision. We took blood samples in order to perform molecular sexing (Fridolfsson & Ellegren 1999). Sex was determined for 53 birds: 22 males and 31 females, mostly those captured in 2018 and 2019. For a few individuals, sex was concluded by observing copulation of colour-ringed birds. Differences among sexes were tested by t-test. All measures of variation in text are presented as mean ± SD.

3. Results and discussion

Morphometric characteristics of adult Common Terns captured on colonies along the Sava and Drava Rivers are given in Table 1. Significant sexual differences were found for head and bill lengths, lengths of bill to skull, and bill depths. Tail length was the only variable that showed a bimodal distribution (Figure 1).

Measured variables were comparable with those reported for other Common Tern populations in Europe and North America (Coulter 1986, Becker & Ludwigs 2004, Lichieri & Spina 2005, Demongin 2016). Becker & Ludwigs (2004) present sex-specific morphometry data of Common

Table 1. Morphometric characteristics of adult Common Terns along the Sava and Drava Rivers. Mean ± SD are given in the first, and range and sample size (N) in the second row. t-test: * $p<0.05$, ** $p<0.005$, *** $p<0.0001$

Tabela 1. Morfometrične značilnosti odraslih navadnih čiger z območja Save in Drave. V prvi vrsti podajamo povprečje ± SD, v drugi vrsti pa rang in velikost vzorca (N). t-test: * p<0,05, ** p<0,005, ***p<0,0001

	All birds	Males	Females	t-test
Wing length / mm	268.7 ± 6.33 252–283, N = 114	268.8 ± 6.49 253–279, N = 21	267.2 ± 6.17 256–280, N = 26	0.878 df = 45
Tarsus length / mm	21.2 ± 0.87 19.4–24.9, N = 127	21.4 ± 1.25 19.4–24.9, N = 22	21.1 ± 0.93 19.5–23.3, N = 29	0.961 df = 49
Head and bill / mm	77.5 ± 2.66 70.3–83.6, N = 128	79.6 ± 2.06 75.7–83.6, N = 21	76.5 ± 2.71 70.3–83.4, N = 30	4.413*** df = 49
Bill length / mm	45.2 ± 2.59 39.0–53.7, N = 128	45.9 ± 2.39 40.8–50.0, N = 21	44.1 ± 2.73 40.2–53.7, N = 30	2.539* df = 49
Bill width / mm	6.0 ± 0.41 5.2–6.9, N = 44	6.1 ± 0.45 5.2–6.9, N = 17	6.0 ± 0.40 5.2–6.8, N = 26	0.419 df = 41
Bill depth / mm	8.4 ± 0.62 7.0–9.7, N = 44	8.7 ± 0.50 8.0–9.7, N = 17	8.2 ± 0.58 7.0–9.7, N = 26	3.005** df = 41
Tail length / mm	149.8 ± 7.82 135.0–165.0, N = 41			
Fork length / mm	82.0 ± 6.17 63.0–98.0, N = 41			
Body mass / g	113.4 ± 7.54 96.0–141.0, N = 125	112.4 ± 7.70 96.0–127.0, N = 21	114.7 ± 7.33 105.0–141.0, N = 29	-1.054 df = 48

Tern populations from the Netherlands, Germany and England. Average wing lengths of adult birds from these populations were 271–273 mm for males and 270 mm for females. Our terns had on average 2–4 mm shorter wings. Lichieri & Spina (2005) gave mean wing length of Common Terns ringed in Italy per decade, with values mostly below 270 mm. The increase in wing length of northern populations and populations with longer migration is in line with both Bergmann's and Seebohm's rules (Berthold 2001). Similar to wing length, tails of Croatian and Slovenian terns are up to 6 mm shorter than in the English population, while tarsus length was similar to north European populations (Becker & Ludwigs 2004).

Body mass shows seasonal variability and circadian fluctuations; therefore differences between populations should be analysed with caution (Hernández *et al.* 2011). Detailed study of body mass change in breeding Common Terns showed that both sexes were heavier during incubation than during the chick-rearing period (Wendeln & Becker 1996). However, our terns were lighter than birds from German Wadden Sea, also weighted during the incubation phase (133 ± 7.2 g for males and 136 ± 8.3 g for females, Becker & Ludwigs 2004). Italian birds were also heavier than Croatian and Slovenian, having mean body mass of 125.6–129.3 g in June (corresponding to the incubation phase) and 109.7–112.6 g in July (Lichieri & Spina 2005).

Head and bill lengths of our population correspond to those measured in populations of England and Scotland. Craik (1999) found that in Scottish population head and bill lengths are the best discriminators between sexes, with mean values for males being 79.79 ± 1.521 mm and for females 75.91 ± 1.792 mm. He suggested that individuals with head and bill lengths >79.0 mm can be identified as males and those with <76.9 as females with 95% confidence. In our studied populations, the difference between sexes in head and bill lengths was also the most significant, but still among 17 birds with known sex having head and bill >79.0 mm, five (29.4%) were females. Contrary, among 18 birds with known sex having head and bill < 76.9, only one (5.5%) was a male. Therefore, in our population, birds with head and bill lengths >79.0 mm could not be sexed as males reliably. Coulter (1986) found sig-

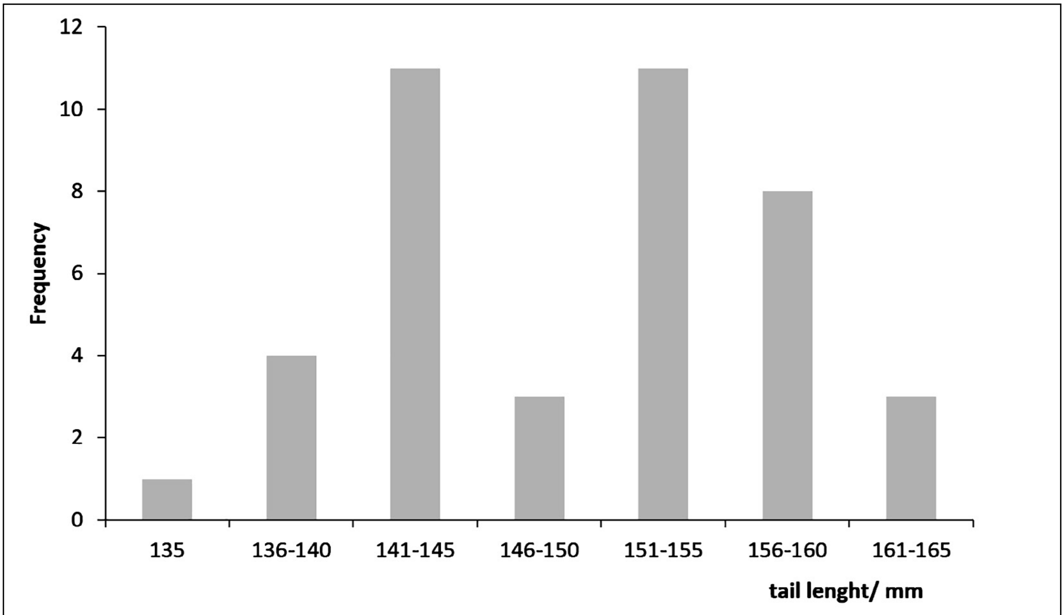

Figure 1. Histogram for the tail length of adult Common Terns sampled in Croatia and Slovenia (N = 41)

Slika 1. Histogram dolžine repa odraslih navadnih čiger iz Hrvaške in Slovenije (N = 41) nificant differences among sexes in bill length, depth and width, based on 55 females and 50 males caught on Great Gull Island (NY, USA). The difference in bill width was shown to be the least significant variable ($P<0.05$) in his, and non-significant in our sample. The bimodal distribution of tail length, characteristic for the presence of two groups, indicates that this variable showed differences between sexes, which was already confirmed in the English population (Becker & Ludwigs 2004). However, the outmost tail feathers are prone to wear, so this measurement can only be used for a limited period. Therefore, in our study tail length was not recorded in 2018 and 2019, when birds were sexed, so sexual differences in tail length could not be given.

Morphometric data of Common Terns breeding in Croatia and Slovenia are presented for the first time. We showed that it is not possible to use values of head and bill lengths proposed on the basis of the Scottish population to determine sexes in the studied population reliably.

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4. Povzetek

To je prvi prispevek, ki podaja morfometrične podatke gnezdečih navadnih čiger iz Hrvaške in Slovenije. Med letoma 2016 in 2019 smo z območja Save in Drave izmerili 130 odraslih navadnih čiger *Sterna hirundo*. Spol smo določili pri 53 osebkih: 22 je bilo samcev, 31 samic. Značilna spolna razlika je bila v meritvah dolžine glave, dolžine kljuna, dolžine glave in kljuna skupaj in višine kljuna. Čigre iz Hrvaške in Slovenije so imele v primerjavi z osebki iz Nizozemske, Nemčije in Anglije nekoliko krajše peruti in rep in so bile nekoliko lažje od ptic iz Nemčije in Italije. Dolžine glave, kljuna in tarzusa so bile podobne kakor pri populacijah iz severne Evrope. V nasprotju z ugotovitvami iz Škotske, razlikovanje spola na podlagi dolžine glave in kljuna (mejna vrednost 79.0 mm) pri hrvaških in slovenskih pticah ni zanesljivo.

Key words: sexual dimorphism, head and bill lengths
Ključne besede: spolni dimorfizem, dolžina glave in kljuna

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First data on breeding success of Croatian inland colonies of Common Tern *Sterna hirundo*

Prvi podatki o gnezditvenem uspehu celinske populacije navadne čigre *Sterna hirundo* na Hrvaškem

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Abstract

In 2018 and 2019, the breeding success of two Common Tern colonies on artificial lakes near the River Sava in Zagreb, Croatia, was studied. The colonies were visited weekly from May to July and we collected data on phenology, number of breeding pairs, clutch size as well as egg and chick survival. We also conducted a comparison between early and late breeders. Hatching and fledging success was within previously observed ranges, apart from a low hatching success on Siromaja in 2019. The smaller colony on Siromaja had a higher productivity in both years than the colony on Rakitje, although in 2018 an avian pox virus killed much of the late chicks on Rakitje. Early breeders seem to have had higher hatching success and average clutch size. Furthermore, a greater proportion of them managed to hatch all their eggs compared to late breeders, but the differences were not statistically significant. Our study provided baseline data for future monitoring of phenology and breeding success with regard to the management of breeding colonies.

1. Introduction

The Common Tern *Sterna hirundo* breeds, often colonially, throughout the Holarctic and winters along seacoasts of South America, Africa, Australia, as well as southern and south-eastern Asia. It inhabits different coastal habitats, but also breeds in freshwater habitats, where it readily accepts artificial sites (Becker & Ludwigs 2004). The Common Tern is a relatively long-lived species, with the oldest ringed bird reported to be 33 years old (Fransson *et al.* 2010). They generally lay 1–3 eggs which they incubate 20–21 days if undisturbed, or 27–28 days in areas with disturbance (Nisbet & Cohen 1975). Chicks wander from the nest after 3 days and fledge 22–28 days after hatching (Nisbet & Drury 1972). In the case of early nest failure, Common Terns usually have replacement clutches (Nisbet & Cohen 1975), often at the same colony (González-Solís *et al.* 1999, Becker & Zhang 2011).

Common Terns breed along the Sava and Drava Rivers in continental Croatia, and on islets in the Adriatic Sea (Kralj *et al.* 2013). Their breeding population of 400–700 estimated breeding pairs (Kralj *et al.* 2013) is classified as near threatened (Tutiš *et al.* 2013). The Common Tern is a target breeding species for 13 Natura 2000 sites in Croatia (Narodne Novine 2019). Breeding population census efforts are, however, reduced to occasional nest counts for inland colonies (Mikuska *et al.* 2017, Kralj *et al.* in print) and rare adult or nest counts along the coast (Lucić *et al.* 2012). Some studies did mention reasons for unsuccessful breeding (Fenyosi 2005), but no investigations of hatching success, fledging success or productivity have thus far been conducted in Croatia. Breeding success monitoring and other demographic indicators in addition to population size can give valuable information for timely problem diagnosis and conservation actions (Szostek & Becker 2012).

We set out to establish breeding success monitoring of our largest inland colonies. The aims of this study were to test breeding success monitoring methodology and to provide first data on Common Tern breeding success and phenology in Croatia.

2. Methods

2.1. Study location

During the 2018 and 2019 breeding seasons, we surveyed breeding success on two Common Tern colonies near Zagreb, Croatia. One was a floating platform set up in mid-May 2018 in Siromaja gravel pit (45°45'23.9"N, 16°11'05.0"E), while the other is an artificial island located in Rakitje gravel pit (45°47'49.8"N, 15°50'24.9"E). Both lakes are located c. 500 m from the Sava River. Common Terns usually arrive to these sites during April and depart through August and September (Kralj *et al.* 2013). We also regularly check other potential breeding sites in the area and count breeding pairs if present (Kralj *et al.* in print).

2.2. Field work

Colonies were either visited or observed weekly from mid-April in order to determine the start of incubation. In case we missed observing this milestone, we estimated it by using the egg-immersion method as described by Hays & LeCroy (1971). After confirming the start of incubation, we did not disturb the colony for two weeks due to high risk of nest desertion (Koffijberg *et al.* 2011). During the third week, we visited the colony and counted the number of nests and eggs per nest. Where following hatching success, we marked as many nests as possible. In 2018 we used bamboo garden markers numbered with a permanent marker to mark the nests, as recommended by Koffijberg *et al.* (2011), while in 2019 we used acrylic paint and permanent markers on pebbles. The reasons for this change are described in results under Monitoring methodology. In 2018 we only marked nests on the platform at Siromaja, whereas in 2019 we marked nests on both colonies. On Siromaja we attempted to mark all observed nests, while on the larger colony at Rakitje we marked a representative proportion following guidelines by Koffijberg *et al.* (2011). We recorded the number of eggs and/or chicks in each nest and their status (observed state, incubation stage), as well as counted all apparently active nests (Walsh *et al.* 1995, Mikuska *et al.* 2007), including non-marked nests on Rakitje. We revisited the colonies each subsequent week and repeated the process, marking any new nest observed on the Siromaja colony. We ringed any chicks observed to be at least two weeks old (Nisbet & Drury 1972) with metal and coloured plastic rings. We also noted the number of dead chicks, documenting those that had been ringed earlier. We stopped visiting a colony when all chicks had fledged.

2.3. Data analysis

The highest number of observed active nests during a single visit was taken as the number of breeding pairs on that colony for the respective season (Walsh *et al.* 1995). The maximum number of eggs per nest was noted as clutch size for that nest for the season, while the number of eggs present in a nest on the last visit before hatching was taken as an estimate of number of hatched chicks. We omitted a nest from the calculations if for any reason we could not estimate the fate of its clutch (e.g. loss or mixing of markings, documented brood size inconsistency, etc.). Hatching success was thus calculated as the estimated number of hatched chicks in monitored nests divided by the total number of monitored eggs. Since it turned out to be impossible to monitor all nests on either colony, we estimated the total number of hatched chicks on a colony with the formula:

Total number of hatched chicks =
breeding pairs × average clutch size ×
monitored nests hatching success

Number of fledged chicks was calculated as all ringed chicks plus any small chicks present during the last visit, subtracted by the number of dead chicks observed with the current year's rings. Dividing the number of fledged chicks with the total estimated number of hatched chicks, we calculated fledging success. Colony productivity was calculated as the number of fledged chicks divided by the estimated number of breeding pairs.

For the colony on Siromaja in 2019 we also compared "early breeders" and "late breeders". "Early breeders" were estimated to be nests first observed before "peak incubation", i.e. the date of the highest observed number of active nests–being 26 May (Walsh *et al.* 1995). "Late breeders" were nests first observed on or after that date, thereby including most of the current year's renesting attempts. This analysis was not performed for either colony in 2018 or for Rakitje in 2019 because the relatively late starting dates for those colonies blurred any distinction between first and subsequent breeding attempts. Yate's corrected Chi square test was used to test differences in breeding success.

3. Results

In 2018, we observed Common Terns regularly on or near their breeding sites from late April. They started incubating on the platform on Siromaja lake in late May, while incubation on the island on Rakitje lake started in mid-June (Table 1). Young fledged through July on Siromaja and from mid-July to late August on Rakitje. In 2019, we regularly observed Common Terns on or near breeding sites from mid-April. On both Siromaja and Rakitje, incubation started in early May. Young fledged

Table 1: Common Tern breeding success across two years on Siromaja and Rakitje, two colonies near Zagreb. Hatching success – estimated number of hatched chicks in monitored nests divided by total number of monitored eggs. Fledging success – number of fledged chicks divided by total estimated number of hatched chicks. Productivity – number of successfully fledged chicks per breeding pair.

Tabela 1: Gnezditveni uspeh navadne čigre v dveh letih na kolonijah Siromaja in Rakitje. Uspeh izvalitve – ocenjeno število izvaljenih mladičev, deljeno s številom gnezd (le gnezda, ki so bila spremljana redno). Uspeh speljave – število speljanih mladičev, deljeno z oceno izvaljenih mladičev. Produktivnost – število speljanih mladičev na gnezdeči par.

	Siromaja		Rakitje	
	2018	2019	2018	2019
start of incubation začetek valjenja	23 May	02 May	mid-June	08 May
last chick ringed obročkan zadnji mladič	26 July	16 July	23 August	05 August
breeding pairs gnezdečih parov	30	39	106	134
monitored nests število nadzorovanih gnezd	23	43	-	43
hatching success uspeh izvalitve	85.29%	69.16%	-	79.41%
mean clutch size povprečna velikost legla	2.77	2.43	-	2.37
% pairs with clutch of 1 % parov z enim jajcem	8.57%	10.00%	-	6.98%
% pairs with clutch of 2 % parov z dvema jajcema	5.71%	36.67%	-	51.16%
% pairs with clutch of 3 % parov s tremi jajci	85.71%	53.33%	-	39.53%
% pairs with clutch of 4 % parov s štirimi jajci	0%	0%	-	2.33%
fledging success uspeh speljave	45.45%	52.17%	-	41.60%
productivity (fledglings/bp) produktivnost (speljanih/gp)	1.0	0.92	0.57	0.78

from early June to mid-July on Siromaja, and from late June to early August on Rakitje.

Lake Rakitje had a colony of an estimated 106 breeding pairs in 2018. Most of the island was flooded until mid-June, so terns started nesting there when parts of the island started resurfacing. We estimate that 61 chicks fledged successfully. On the last day of ringing we observed 21 dead chicks and 3 dead adults on the colony.

The colony on lake Rakitje had an estimated 134 breeding pairs in 2019. Based on 43 monitored nests, 81 out of 102 monitored eggs hatched. From this we extrapolated an estimated 293 eggs that successfully hatched on the whole colony that year. Of the 43 monitored breeding pairs, one had a clutch of four eggs, 17 had clutches of three, 22 were clutches of two and 3 had clutches of one egg. 30 of the pairs (69.8%) managed to hatch all their eggs. The colony successfully fledged 105 chicks.

On the platform at Siromaja lake we estimated 30 breeding pairs of Common Terns in 2018. Based on 23 successfully monitored nests, 58 out of 68 monitored eggs hatched successfully. We estimate that 8 more unmonitored eggs hatched. Of the 23 monitored breeding pairs, 15 (65.22%) managed to hatch all their laid eggs. During the season we observed 30 clutches of 3 eggs, two clutches of 2 eggs and three clutches with only one egg. The total number of fledged chicks at the colony was 30.

In 2019 we estimated 39 pairs of Common Terns to be breeding on the Siromaja colony. Based on 43 monitored nests (some obviously being re-nesting attempts), 74 out of 109 monitored eggs hatched. We estimate an additional 32 eggs to have hatched. Of the 43 monitored breeding pairs, 22 (51.63%) managed to hatch all their laid eggs, 19 of them being early breeders and 3 late. Considering early versus late breeder performance (Table 2), the difference in hatching success was not significant ($\chi^2 = 0.77$, df = 1, $P = 0.380$) and neither was the proportion of pairs with all hatched eggs ($\chi^2 = 1.36$, df = 1, $P = 0.244$). Considering all nests observed on the colony, they had an average clutch size of 2.43 eggs, with 32 clutches of 3 eggs, 22 clutches of 2 eggs and six with only one egg. Among those, early breeders had 23, 8 and 3 clutches of 3, 2 and 1 eggs respectively, while late breeders had 9, 14 and

Table 2: Comparison of early versus late breeder breeding success on a breeding platform near Zagreb in 2019. "Early breeders" were estimated to be nests first observed before the date when we counted the greatest number of active nests on the colony (26 May), while "late breeders" were nests first observed on or after that date. Difference significance is given as p-value of Yate's corrected Chi square test.

Tabela 2: Primerjava gnezditvenega uspeha med zgodnjimi in poznimi gnezdilci na gnezdilnem splavu pri Zagrebu v letu 2019. Pri zgodnjih gnezdilcih so bila gnezda najdena pred datumom, ko je bilo na gnezdišču največ gnezd (26. maj), pri poznih so bila gnezda najdena prvič na ta dan ali kasneje. Značilnost razlike je prikazana s Hi-kvadrat testom in Yeatsovim popravkom.

Siromaja 2019	early breeders zgodnji gnezdilci	late breeders pozni gnezdilci	difference significance značilnost razlike
hatching success uspeh izvalitve	72.78%	53.85%	p = 0.38
nests with 100% hatched eggs gnezda s 100% izvaljenimi jajci	63.33%	23.08%	p = 0.24
mean clutch size povprečna velikost legla	2.59	2.23	
% pairs with clutch of 1 % parov z enim jajcem	8.82%	11.54%	
% pairs with clutch of 2 % parov z dvema jajcema	23.53%	53.85%	p = 0.23
% pairs with clutch of 3 % parov s tremi jajci	67.65%	34.62%	

3 clutches of 3, 2 and 1 eggs respectively. The difference was not significant ($\chi^2 = 6.81$, df = 5, $P = 0.23$). The total number of fledged chicks at the colony was 36.

Monitoring methodology

Regarding nest marking, in 2018 terns used some of the bamboo garden markers as nest material. This disabled identification of nests, the markers of which had been taken, as well as of nests containing multiple markers. Additionally, towards the end of the breeding season, some markings faded away and became impossible to read. For these reasons we were unable to follow 7 out of 34 (20.59%) marked nests until the end of the study. In 2019, when using pebbles with acrylic paint, we only lost track of 2 out of 42 (4.76%) marked nests.

4. Discussion

Arrival of Common Terns to the colonies around Zagreb in both years and the start of incubation in 2019 coincide with those observed along the Po River (Bogliani & Barbieri 1982), as well as in central Poland (Minias *et al.* 2015). They occurred about 10 days earlier than those observed in populations breeding along the North Sea (Becker & Zhang 2011, Dobson *et al.* 2017) and more than two weeks earlier than populations in south-eastern Massachusetts (Nisbet & Drury 1972) and the Danish Wadden Sea (Bregnballe *et al.* 2015). In 2018, birds started incubating between four and six weeks after they had started congregating near their breeding sites, while in 2019 incubation started two to three weeks after arrival. Time between arrival and laying for 2019 corresponds to that observed previously (Becker & Zhang 2011), but in 2018 the pre-laying period lasted longer. The most probable cause for this are extremely high spring water levels that occurred in 2018 in Croatia, flooding all potential breeding sites (Kralj *et al.* in print). Common Terns therefore did not have any suitable breeding sites in the area until we set up the floating platform at lake Siromaja in mid-May, while their traditional colony resurfaced only in mid-June.

All mean clutch sizes are within the range described by previous studies in England (Langham 1972, Bullock & Gomersall 1981), western Germany (Witt 1970), Denmark (Bregnballe *et al.* 2015) and Poland (Minias *et al.* 2015).

Hatching success on Siromaja in 2018 and Rakitje in 2019 was within the range described by previous studies in western Germany (77%, Witt 1970), southern Finland (80%, Lemmetyinen 1973) and northern Germany (73%, Becker *et al.* 1993). However, hatching success in the Siromaja colony in 2019 was smaller than that of a "highly contaminated" colony in northern Germany (68%, Becker *et al.* 1993), found in 1988 to have had a critical level of organochlorines which reduce hatchability (Fox 1976). Since there are many potential factors which can influence hatchability (Burger & Gochfeld 2003), we propose further monitoring of hatching success on the colony, as well as a toxicological survey of eggshells.

Considering early and late breeders on Siromaja in 2019, there was no statistically significant difference between early and late breeder clutch size and hatching success. Becker & Zhang (2011) did not find any differences in breeding success between early and late breeders either, while Bregnballe *et al.* (2015) found that early breeders had larger clutches. Continued monitoring of early and late breeder breeding success is required to elucidate whether there are any significant differences.

Fledging success and productivity were smaller than observed in older studies (Witt 1970, Langham 1972, Lemmetyinen 1973), but productivity was in line with other studies (Nisbet & Drury 1972, Hays 1978, JNCC 2016). Observed high mortality and consequential low fledging success on Rakitje in 2018 have later been connected to an avian pox virus infection diagnosed from dead birds (Savić *pers. comm.*). Minias *et al.* (2015) observed higher productivity in a large colony compared to smaller ones, although chicks from the larger colony were in poorer condition. They attributed the difference to opposing selective pressures – higher predation on smaller colonies versus higher parasitism/social stress on the larger ones. However, we observed an opposite situation regarding productivity. Lower apparent productivity on Rakitje (the larger colony) in comparison to Siromaja might be a result of habitat type differences. Chicks are protected from terrestrial and aquatic predators on the fenced floating platform on lake Siromaja. On the other hand, the island on lake Rakitje has dense patches of reeds, willow and poplar around its edges. While these patches provide chicks with cover from predators, they also enable them to hide from researchers, thus potentially lowering the surveyed number of fledglings on the colony. We recommend a study of fledgling condition on these colonies to further test the conclusions from Minias *et al.* (2015).

According to breeding success data, Siromaja and Rakitje seem like average Common Tern breeding colonies. They thus represent a valuable opportunity to monitor and research Common Tern population dynamics, ecology and ethology.

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5. Povzetek

V letih 2018 in 2019 smo raziskovali gnezditveni uspeh na dveh kolonijah navadne čigre v bližini Save pri Zagrebu. Kolonije smo obiskovali tedensko od maja do julija. Zbirali smo podatke o fenologiji, številu gnezdečih parov, velikosti legla in preživetju jajc ter mladičev. Primerjali smo podatke z zgodnjih in poznih gnezd. Uspešnost izvalitve in speljave sta bili v rangu prejšnjih opazovanj z izjemo nizkega uspeha speljave na Siromaji leta 2019. Manjša kolonija na Siromaji je imela v obeh letih višjo produkcijo mladičev kot kolonija na Rakitju. Leta 2018 je zaradi virusa na Rakitju poginilo veliko mladičev. Zgodnji gnezdilci so imeli večji uspeh izvalitve z večjim leglom, večji delež jih je izvalil vsa jajca v primerjavi s poznimi gnezdilci, a razlike statistično niso bile značilne. Naša raziskava je osnova za nadaljnje preučevanje fenologije in gnezditvenega uspeha predvsem pod vplivom naravovarstvenih ukrepov.

Keywords: phenology, clutch size, hatching success, fledging success, productivity

Ključne besede: fenologija, velikost legla, izvalitveni uspeh, uspeh speljave, produkcija

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37 let gnezdenja navadne čigre *Sterna hirundo* v Sečoveljskih solinah

37 years of Common Tern *Sterna hirundo* breeding at Sečovlje Salina

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Povzetek

V Sloveniji je navadna čigra *Sterna hirundo* nekoč gnezdila ob večjih vodotokih, danes gnezdi samo še lokalno na gnezdiščih umetnega nastanka. Na morskem obrežju je bila gnezditev navadne čigre prvič potrjena leta 1983, ko je v Sečoveljskih solinah gnezdilo 9 parov. V istem letu smo pričeli s kartirnimi popisi gnezdilcev v Sečoveljskih solinah, ki nepretrgano trajajo še danes. Od leta 2010 sistematično zbiramo podatke o številu speljanih mladičev. Leta 1991 se je število gnezdečih parov povečalo, kar se ujema s povečanjem v drugih krajih Sredozemlja. Po letu 1991 je velikost njene gnezditvene populacije dokaj stabilna in znaša od 30 do 70 parov. Gnezditveni uspeh navadne čigre v Sečoveljskih solinah je slab, večinoma zaradi padavin (40 % vseh propadlih gnezd) in plenjenja (35%). Dolga sušna obdobja brez padavin ugodno vplivajo na uspeh izvalitve in speljave mladičev. S primernim vodnim režimom, umetnimi otoki in nadzorom dostopa do gnezdišč lahko preprečimo motnje obiskovalcev in delno tudi plenilcev, kot sta lisica in kuna. Na Sečoveljskih solinah je preživetje navadne čigre povsem odvisno od aktivnega upravljanja. Pričakovane podnebne spremembe s pospešenim dviganjem morske gladine in posledično pogostejšim poplavljanjem nizko ležečih območij njen obstoj in preživetje v Sečoveljskih solinah še dodatno otežujejo.

1. Uvod

Navadna čigra *Sterna hirundo* v Evropi ne velja za ogroženo vrsto, čeprav so se v nekaterih državah zaradi degradacije habitata, motenj, ki jih povzroča človek, in drugih dejavnikov velikosti populacij močno zmanjšale (BirdLife International 2015). Pri nas sodi med vrste, ki potrebujejo aktivno varstvo in upravljanje (Denac *et al.,* 2019). Uvrščena je na Rdeči seznam ogroženih gnezdilk Slovenije kot močno ogrožena vrsta (E2; Ur. list 2002).

Navadna čigra v Sloveniji gnezdi v obpanonskih pokrajinah in na Obali (Denac *et al.,* 2019). V Sečoveljskih solinah gnezdi od leta 1983 dalje, medtem ko je v Škocjanskem zatoku pričela gnezditi leta 2007 po njegovi renaturaciji. Je edina vrsta ptice pri nas, ki nam jo je z naravovarstvenimi ukrepi uspelo ohraniti, potem ko je zaradi človekovih posegov v osemdesetih letih prejšnjega stoletja že skoraj izginila (Škornik, 2012 a). Vzroki za upad populacij navadne čigre na območjih gnezdenja so dobro poznani. Grožnje lahko razdelimo na dejavnike, ki na velikost populacij vplivajo neposredno (plenjenje gnezd, kompeticija z drugimi vrstami, naravoslovni turizem), ter dejavnike, ki vplivajo na velikost populacij posredno (uničevanje habitatov, zaraščanje ustreznih gnezdišč z vegetacijo, turizem in obiskovanje, nevarnost trka, botulizem ...) (Škornik, 2012 a).

2. Metode dela

Podatki o navadni čigri so bili zbrani na območju Krajinskega parka Sečoveljske soline (KPSS). Sečoveljske soline so nacionalno pomembno območje velike naravne, kulturne, ekonomske in estetske vrednosti, kjer je možno s sonaravnim gospodarjenjem vzdrževati in uravnavati veliko biološko raznolikost (Škornik, 2013).

Podatke o gnezdenju navadne čigre smo zbirali z načrtnimi kvantitativnimi popisi v mreži UTM 100 × 100 m. Od leta 1983 do leta 2019 smo v gnezditvenem času območje Sečoveljskih solin natančno pregledali po vsej površini, primerni za gnezdenje. Vodnih površin brez blatnih otočkov nismo pregledovali. Od skupno 787 kvadratov velikosti 100 × 100 m jih je nekaj manj kot 500 primernih za gnezdenje. Pri delu na terenu smo občasno uporabljali tudi različna plovila. Podatke, ki smo jih zbrali s pomočjo GPS-sprejemnika, kakor tudi starejše podatke smo prav tako prenesli v popisno mrežo 100 × 100 m. Od leta 2010 sistematično zbiramo tudi podatke o številu speljanih mladičev.

Oceno populacijskega trenda navadne čigre na območju Sečoveljskih solin smo izračunali s pomočjo programa TRIM - Trends and Indices for Monitoring data, različica 3.54 (Pannekoek & van Strien 2001).

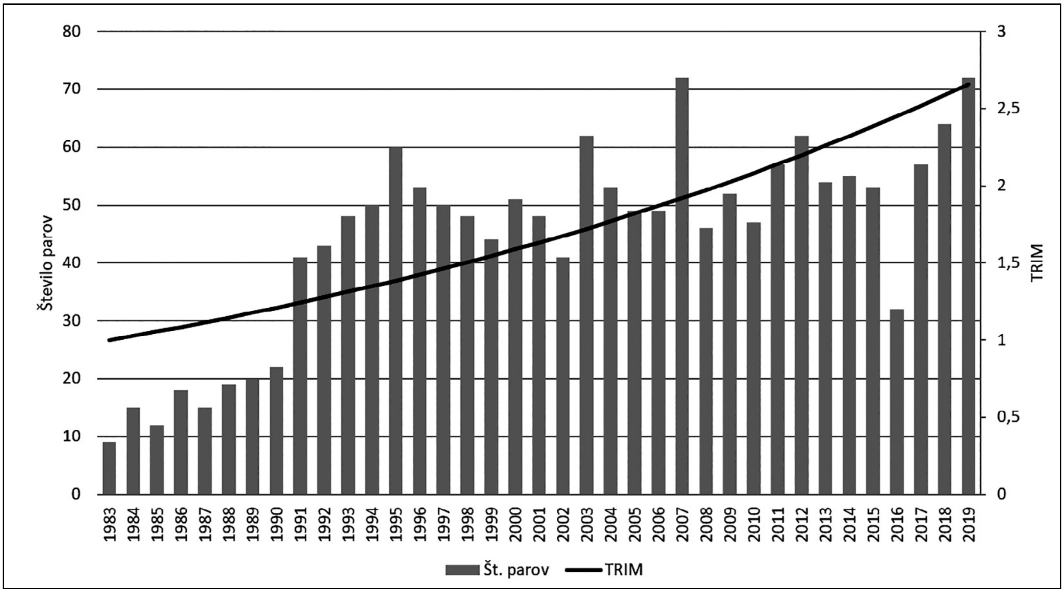
3. Rezultati in diskusija

3.1. Gnezdenje

Na območju Sečoveljskih solin je navadna čigra prvič gnezdila v letu 1983, ko je na nasipu med kanaloma Curto in Pichetto gnezdilo 9 parov (Škornik, 1983). Leta 1991 se je število gnezdečih parov skokovito povečalo (Škornik *et al.,* 1995), kar se ujema s povečanjem velikosti populacij iz drugih krajev Sredozemlja, predvsem solin, kjer ta vrsta gnezdi. Za tak trend gre vzroke iskati tudi v številnih novih, majhnih, umetno nastalih otokih v industrijskih in drugih solinah (Walmsley, 1997). Po letu 1991 redno gnezdi od 30 do 70 parov (Slika 1). Velikost gnezditvene populacije sicer niha, a je dolgoročno stabilna. V celotnem obdobju od leta 1983 dalje je populacija v zmernem porastu (TRIM: P <0.01). Glavnina gnezdeče populacije je na dveh območjih v KPSS: nasip v bazenu Curto-Pichetto ter območje Life med kanalom Pichetto in Letališčem z blatnimi in delno poraščenimi otočki (Slika 2).

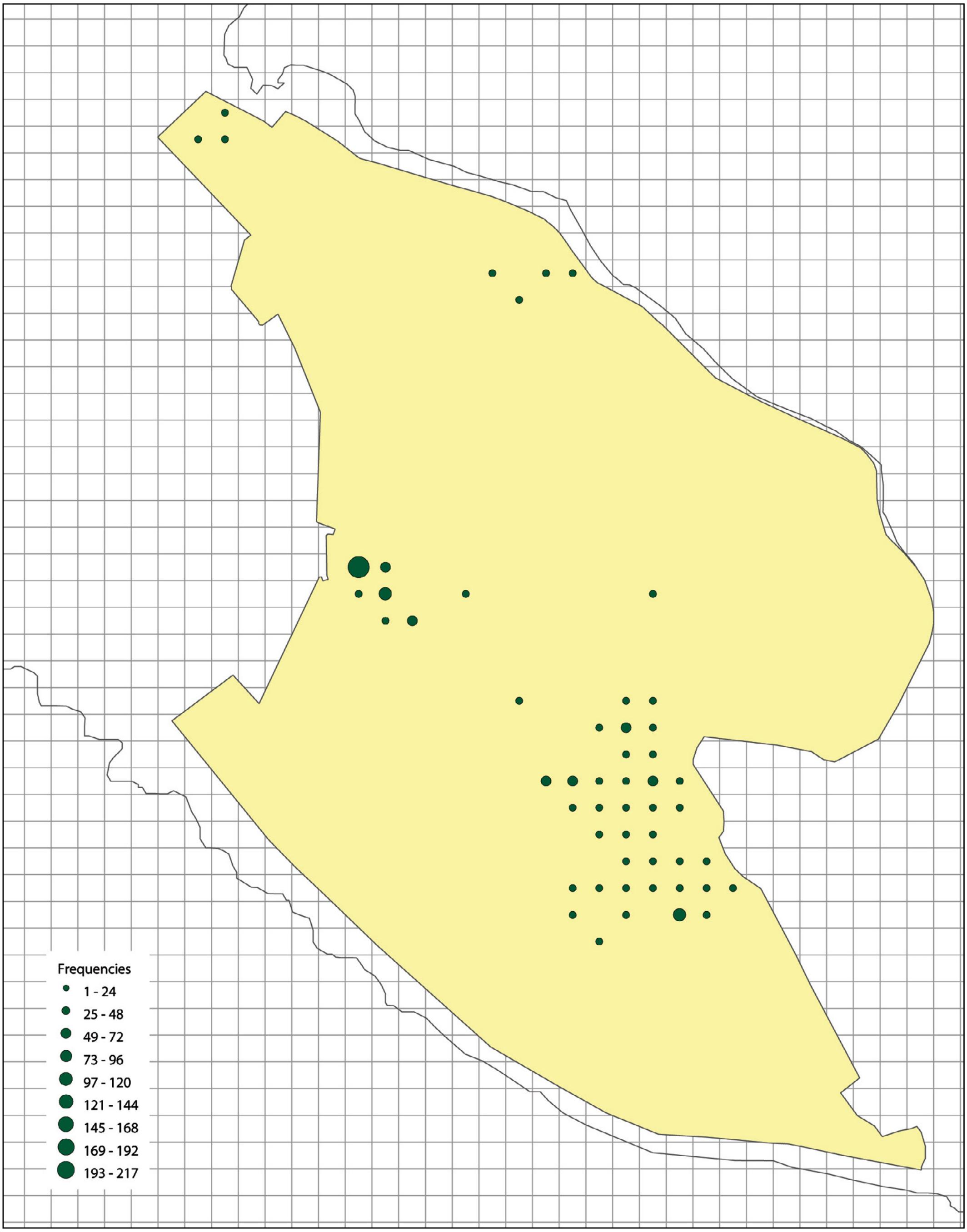
Navadno čigro v Sečoveljskih solinah v največji meri ogrožajo vremenske ujme s poplavami (40% vseh propadlih gnezd), plenilci (35%), proizvodnja soli (10%), vzdrževalna dela (10%) ter obiskovanje in rekreacijske dejavnosti (5%) (Škornik, 2017).

V drugi polovici 21. stoletja je zaradi podnebnih sprememb pričakovati tudi pospešeno dviganje morske gladine in posledično pogostejše poplavljanje nizko ležečih obrežnih območij. Slednje bi lahko imelo pomembne posledice tudi za ptice, ki se v teh habitatih prehranjujejo v času selitev, v njih gnezdijo ali prezimujejo (Ivanjšič *et al.,* 2017). Analize gnezditvenih vzorcev nekaterih ptic gnezdilk (beločeli deževnik, mala in navadna čigra ter polojnik) v KPSS so pokazale, da dinamika gnezdenja



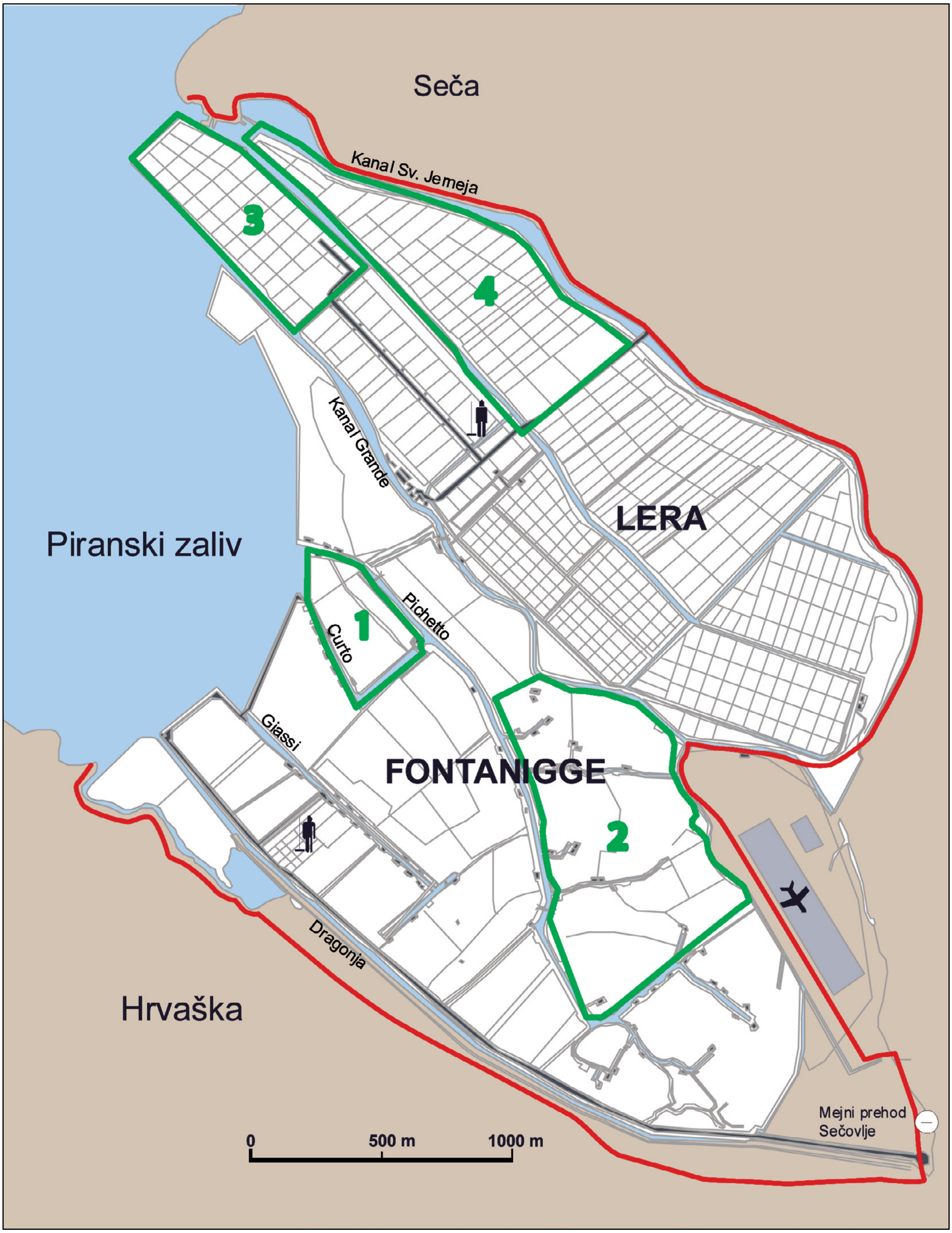
Slika 1: Število gnezdečih parov navadne čigre in trend populacije v obdobju 1983 do 2019

Figure 1: Number of breeding pairs of Common Tern and its population trend in the 1983–2019 period



Slika 2: Kumulativno število gnezd navadne čigre po 100 × 100 m kvadratih v obdobju 1983–2019 (frekvence = rang števila gnezd)

Figure 2: Cumulative number of Common Tern nests in 100 × 100 m squares in the 1983–2019 period (frequencies denote range of number of nests)



Slika 3: Območja Sečoveljskih solin: 1 = območje Curto-Pichetto; 2 = območje Life; 3 = območje Piccia; 4 = območje Mezzana

Figure 3: Sečovlje Saltpans areas: 1 = Curto-Pichetto area; 2 = Life area; 3 = Piccia area; 4 = Mezzana area

teh ptic v zadnjih letih na te probleme že opozarja (Ivanjšič *et al.,* 2017). Brez ustreznega vzdrževanja vodnega režima in urejanja primernih gnezditvenih površin lahko navadna čigra izgine kot gnezdilka Sečoveljskih solin.

3.2. Glavni gnezditveni poudarki

V gnezditveni sezoni leta 1995 se je navadna čigra zaradi obilnega dežja in s tem povezanih visokih voda iz območja Fontanigge preselila v predel Lere, kjer prej nikoli ni gnezdila, in na območje med kanaloma Curto in Pichetto, kjer je prvič gnezdila leta 1983 (Makovec *et. al,* 1998; za položaj območij glej sliko 3). Leta 2002 in 2004 so ujme z močnim deževjem dobesedno pometle s čigrami in drugimi gnezdečimi vrstami. V letu 2002 smo v okviru projekta ALAS (All About Salt) postavili 8 gnezditvenih splavov, na katerih so navadne čigre uspešno gnezdile vse do leta 2004. Tega leta je na splavih začelo gnezditi 21 parov, a sta dve zaporedni nevihti z močnim vetrom v juniju populacijo povsem uničili. Ta se je kasneje preselila na staro gnezdišče med kanaloma Curto in Pichetto, kjer so ptice v drugo gnezdile uspešno. V gnezditveni sezona 2003, ko je prevladovalo dolgo in sušno obdobje, je preživela večina gnezd (Škornik, 2004).

Splave smo leta 2006 razstavili in na osrednjem območju na Fontaniggah, ki so ga leta 1998 T. Makovec, I. Škornik in L. Lipej predlagali kot ornitološki rezervat z najstrožjim varstvenim režimom (Makovec *et al.,* 1998), uredili gnezdišče, poimenovano »Life«. Okoli območja smo izkopali širok in globok jarek, ki je nekoč že obrobljal solna polja in preprečuje dostop kopenskim plenilcem do gnezdišč ter zagotavlja boljši pretok in izmenjavo vode. Ugotovili smo, da lahko predvsem z nadzorom nad višino vode v omenjenem območju zagotovimo ustrezne gnezditvene razmere za navadno in malo čigro *Sternula albifrons*, polojnika *Himantopus himantopus* ter sabljarko *Recurvirostra avosetta* (Škornik, 2012).

Leta 2006 smo na območju Lere, imenovanem Piccia, postavili še eno gnezdišče za čigre. Gnezdišče obsega skupaj 5000 m^2 površine, od tega pokriva površina 15 otokov kar 1500 m^2. Območje, ki smo ga zalili z morsko vodo, pa je še večje. Čigre gnezdišča niso zasedle, zato smo leta 2008 nanj postavili glinene čigre ter ozvočenje s predvajalnikom, kar naj bi čigre privabljalo. Nadomestnih gnezdišč kljub vsemu čigre niso zasedle. Vzrok za to bi lahko bilo tudi pojavljanje sivih vran *Corvus cornix.* Opazili smo namreč, da so vrane glinene čigre skljuvale in obglavile. Poškodbe, narejene s kljunom, so bile pogoste v predelu oči, vratu in na trebuhu (Škornik, 2009). Ob pregledu gnezditvenih otokov smo opazili globelice v pesku, ki so jih nedvomno naredile čigre ob poskusu gnezdenja, vendar domnevamo, da so namero zaradi sivih vran opustile.

Leta 2007 smo po končani sezoni opazili le nekaj speljanih mladičev. Čigre so imele najmanj dve nadomestni legli, ob tem pa so najmanj dvakrat zamenjale območje gnezdenja. Večina jajc je propadla zaradi vremenskih razmer, nekaj legel so izropale sive vrane in lisice *Vulpes vulpes*, svoj davek pa je zahteval tudi pojav botulizma, ki je bil potrjen na 4 kadavrih male čigre (Škornik, 2007). V letu 2008 je navadna čigra gnezdila le na nasipu območja Curto-Pichetto in posamič na območju LIFE.

Nevihta s točo in močnim vetrom, ki je divjala 13. 6. 2012, je na gnezdiščih čiger pustila razdejanje. Ob pregledu smo ugotovili, da je tretjina nekaj dni starih mladičev navadne čigre poginila, poškodovanih je bilo tudi nekaj jajc, medtem ko je bilo pri mali čigri poškodovanih skoraj 90% legel - mala čigra gnezdi kasneje kot navadna čigra in v času toče mladičev še ni bilo. Konec junija je 95% preostalih čigrinih mladičev uplenila kuna belica *Martes foina*, kar so pokazali sledovi v blatu ter način usmrtitve (Škornik, 2013). Nadomestnih legel čigre niso imele. Tudi v letu 2013 in 2014 je bil uspeh slab, skupaj se je speljalo le 9 mladičev navadne čigre (Tabela 1).

Leta 2015 se ni speljal niti en sam mladič. Dve lisici sta uplenili legla in požrli vse mladiče, kar so zabeležile tudi lovske foto pasti. Čigre so gnezdile večinoma na območju Life, ki pa je bilo zaradi gradbenih posegov v solinah povsem suho. Pred tem smo poizkusno postavili zaščitne mreže na gnezda čiger, ki bi preprečile plenjenje srak in sivih vran, vendar se je ukrep izkazal kot nepotreben, saj v času gnezdenja na gnezdišču ni bilo opaziti sivih vran in srak. Po izvalitvi mladičev smo zaščito odstranili, saj starša nista znala krmiti

Tabela 1: Število speljanih mladičev na gnezdeči par

Table 1: Number of fledged birds per breeding pair

leto / year	parov pairs	speljanih mladičev fledged birds	mladičev na par fledged birds per pair
2019	72	37	0.51
2018	64	15	0.23
2017	57	31	0.54
2016	32	3	0.09
2015	53	0	0.00
2014	55	4	0.07
2013	54	5	0.09
2012	62	44	0.71
2011	57	17	0.30
2010	47	53	1.13
skupaj/ povprečno total/ average	553	209	0.38

mladičev skozi mrežo. Po plenjenju lisic se je nekaj parov navadnih čiger premaknilo na območje zgoščevanja morske vode na Leri, kjer so gnezdili v drugo, vendar so jim lisice tudi tu požrle vsa jajca.

V letu 2016 je na območju KPSS gnezdilo 32 parov navadne čigre, kar je bilo najmanj po letu 1990. Gnezditveni uspeh je bil zaradi plenjenja lisice in srak, ki so gnezdile v neposredni bližini otokov, majhen. Čigre so gnezdile večinoma na otokih območja Life, ki je bilo ustrezno zalito z vodo. Leta 2017 se je speljalo 31 mladičev. Leta 2018 so gnezda plenile lisice, rumenonogi galebi *Larus michahellis*, kragulj *Accipiter gentilis* in navadna postovka *Falco tinnunculus*. Kragulj je plenil tudi odrasle osebke, kar je bilo dokazano že v letu 2017 (Škornik, 2018). Na območju LIFE so čigre imele nadomestna legla, saj je prva v celoti izplenila lisica. Iz drugih legel so se speljali 3 mladiči. Na starem gnezdišču med kanaloma Curto-Pichetto, ki je bilo po naravovarstvenih posegih obkroženo s primerno globino vode, je poletelo 13 mladičev.

V letu 2019 je 61 parov navadnih čiger gnezdilo na starem gnezdišču med kanaloma Curto in Pichetto, 11 na območju Life. Speljalo se je dvakrat več mladičev kakor v letu 2018.

3.3. Gnezditveni uspeh in označevanje čiger

V obdobju 2010–2019 smo podrobno spremljali gnezditveni uspeh navadnih čiger na območju Sečoveljskih solin (tabela 1). Le ta je znašal od 0 do 1,1 mladiča/par (povprečno 0,37 mladiča/par). Najslabši gnezditveni uspeh smo zabeležili leta 2015, ko se ni speljal niti en sam mladič, najboljši gnezditveni uspeh pa leta 2010 (1,1 mladiča/par).

V obdobju 2003–2019 smo obročkali 294 mladičev navadne čigre. Leta 2004 obročkano navadno čigro so še isto leto (13. 11. 2004) ulovili v Senegalu (Škornik, 2012), isto leto je bil drug osebek opazovan v Italiji. Leta 2010 smo pričeli z barvnim obročkanjem. S plastičnimi PVC-obročki s kodo smo opremili 227 mladičev navadne čigre. Število ponovno opaženih čiger se je povečalo. Največ najdb je iz območja izliva reke Soče, nekaj opazovanj je tudi z drugih mokrišč Italije, Francije, južne Španije ter Hrvaške Istre v okolici Rovinja. S pomočjo barvnega zaznamovanja smo ugotovili, da na območju Sečoveljskih solin gnezdijo tudi nekatere čigre, ki so se izvalile tu ali v bližnjem Škocjanskem zatoku. Prav tako smo tu registrirali gnezditev čigre z italijanskim obročkom.

Abstract

Years ago, the Common Tern *Sterna hirundo* was known to nest in Slovenia along larger watercourses. Today it only breeds locally in artificially built nesting areas. On the seashore, its nesting was confirmed for the first time in 1983, when 9 pairs bred in the Sečovlje Saltpans. In the same year, we started mapping the breeders in the Sečovlje Saltpans, which has continued till this very day. Since 2010, we have been systematically collecting data on the number of fledged birds. In 1991, the number of breeding pairs increased, which coincides with the increase in other parts of the Mediterranean. Since 1991, the size of the breeding population has been quite stable, ranging from 30 to 70 pairs. The Common Tern's breeding success in the Sečovlje Saltpans is poor, mainly due to precipitation (40% of all unsuccessful nests) and predation (35%). Long, dry periods without rainfall have a positive effect on the hatching and fledging success. Appropriate water management, artificial islands and access to nesting sites control

can prevent the disturbance caused by visitors and, in part, predators such as foxes and martens. At the Sečovlje Saltpans, the Common Tern's survival depends entirely on the active management. The expected climate change, with increasing sea level rise and consequently more frequent flooding of low-lying areas, further aggravates its existence and survival in the Sečovlje Saltpans.

Ključne besede: navadna čigra, Sečoveljske soline, gnezdenje
Key words: Common Tern, Sečovlje Saltpans, breeding

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Iz ornitološke beležnice

From the ornithological notebook

NAVADNA ČIGRA / COMMON TERN

Common Tern *Sterna hirundo*

Navadna čigra - prvo gnezdenje na ribnikih za vzgojo krapov v Poljani pri mestu Garešnica (Hrvaška)

The carp fishponds of Poljana (45°31'09.8"N 16°56'43.4"E) are located in the central part of Croatia near the town of Garešnica. They are among the oldest and largest fishponds in Croatia, created in 1902 and now covering an area of more than 1000 ha (Bojčić *et al.* 2002). During the breeding bird surveys carried out in spring and summer of 2019, a breeding colony of Common Tern *Sterna hirundo* was spotted on the fishponds with an estimated 10–15 breeding pairs. This is the first record of Common Tern breeding at Poljana fishponds.

Common Terns were first observed on 11 May 2019, resting on an island with a few pairs of breeding Black-headed gulls *Larus ridibundus*. It was not until my second visit on 20 July 2019 that breeding was confirmed. Adult birds were seen feeding their chicks and making alarm flights to protect the colony from predators. Most of the chicks were already able to fly by that time, but some of them were still in the pullus phase.

The colony is located on one of the islands in the northeastern part of the fishponds. These manmade islands consist of mud and have a flat surface. While most of the islands are covered with low vegetation, the one with the Common Tern colony was clearly more open (Figure 1). As this part of the fishponds is not used anymore for commercial purposes, disturbance levels are low. Only recreational fishermen still visit this part to fish from the shore, but this is at least 220 meters from the island. As Common Terns tend to return to the same breeding colony each year, it is likely they will be back next spring if conditions are suitable again (Austin 1949).

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Figure 1 / Slika 1: Breeding colony of Common Terns on the carp fishponds of Poljana, Croatia on 20 Jul 2019 / Gnezdilna kolonija navadne čigre na ribnikih v Poljani, Hrvaška – fotografirano 20. 7. 2019 (foto: B. Ječmenica)

Common Tern *Sterna hirundo*

Navadna čigra – 286 osebkov opazovanih dne 17. 6. 2010 na Ormoškem jezeru (Slovenija); največje število osebkov, kar jih je bilo kdaj zabeleženih na tej lokaciji, je domnevno vključevalo znaten del negnezdečih osebkov oz. osebkov, ki niso izvirali iz slovenske gnezdeče populacije.

In 2010, Common Terns bred at two locations in the Ormož area: (1) partly dried basins of the former Ormož Sugar Factory (37 pairs), and (2) artificial structures situated on nearby Lake Ormož reservoir (35 pairs) (Denac *et al.* 2010). Consequently, around 100 individuals (max. 111 on 25 May 2010) were usually observed at the Lake during our regular waterbird counts throughout the breeding season between mid-April and early June (*own unpubl. data*). However, during the evening visit on 17 June 2010, 286 individuals were counted between 19.45 and 20.30 hrs while feeding on emerging insects low over the water surface. This is the largest congregation observed at Lake Ormož and one of the highest Common Tern numbers registered during a single count on the Drava River in Slovenia so far. The observation apparently included a considerable number of non-breeding individuals or individuals that were not part of the Slovenian breeding population, as the record substantially exceeds the total number of breeding birds in this part of the country in 2010 (128 pairs) (Denac *et al.* 2010).

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Common Tern *Sterna hirundo*, Yellow-legged Gull *Larus michahellis*

Navadna čigra, rumenonogi galeb – par navadne čigre je leta 2017 neuspešno gnezdil na otočku Crna seka v bližini nacionalnega parka Mljet (Hrvaška). Na otoku je bilo v istem letu zabeleženih tudi pet neletečih mladičev rumenonogih galebov.

One pair of Common Terns was breeding from 2007 until 2016 on Crna seka islet (0.11 ha), close to Pomena in Mljet National Park. Also in the beginning of May 2017, birds started to breed on the island. On 3rd June a nest was abandoned and we found one of the Common Tern adults dead near it. The dead tern had wounds on its back, pointing at a violent death. On the islet we found 5 non-flying pulli of Yellow-legged Gull. It was the first time in the 2007–2017 period that Yellow-legged Gulls bred on this small islet and we presume that the adult Common Tern was killed by them.

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Common Tern *Sterna hirundo*

Navadna čigra – dne 6. 6. 2017 zabeleženih 5 gnezdečih navadnih čiger na prodnatem otočku v Predorski Bari pri naselju Jagodina (Srbija, UTM EO27). Trije pari so imeli po enega mladiča, dva para po dva.

In spring/summer 2017, I observed a nesting Common Tern Sterna hirundo on the Predorska Bara (UTM EP27) pond, which is located on the left bank of the Velika Morava River near the village of Končarevo some 9 km east of Jagodina (Serbia). Predorska Bara was visited for the first time on 6 June when 5 couples with fledglings were registered and observed. The nests were located on 2 small pebble island in the middle of the pond. The larger island was overgrown with American acacia *Amorpha fruticosa* and had 4 nesting pairs. On the smaller island, 150 m away, one pair was observed. This isolated couple nested in company with a pair of Little Ringed Plovers *Charadrius dubius*. Three pairs of terns had one chick per nest, and two pairs had two chicks per nest. Adults were preying on small fishes in the pond and in the river nearby. The colony was observed from the shore of the pond at a distance of about 100 m. The birds seemed highly disturbed owing to my presence. The colony was visited 4 more times: in June 19; July 5, 18 and 26. In mid-August the terns left the pond. The pond that covers about 12 ha was created by excavation of gravel. Predorska Bara had been visited in previous years as well, but now the nesting of Common Tern was recorded for the first time. In recent studies, this is the second recorded nesting site of Common Tern in the

Figure 2 / Slika 2: Dead Common Tern adult / Poginuli odrasli osebek navadne čigre (foto: L.Jurinović)

Figure 3 / Slika 3: Common Tern with hatchling on a small island on the Predorska Bara pond (Serbia) / Navadna čigra z mladičem na majhnem otoku sredi ribnika Predorska Bara (Srbija) (foto: B.STanković) vicinity of Jagodina. The first is about 15 km downstream in the Velika Morava valley, near Bagrdan (Radaković, 2009), also at the gravel pond where one pair nested in 2019 (pers. obs.).

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Navadna čigra *Sterna hirundo*

Common tern – on small Mišnjak island near the village Mandre on the island of Pag (Croatia), 10–15 pairs of Common Terns observed nesting in 2011 and up to 20 in 2012.

Otok Mišnjak (centroid: 44,499622°, 14,896130°), okoli 0,6 ha zelo skopo poraščene kopnine pri naselju Mandre na otoku Pagu (Hrvaška), je znano gnezdišče navadne čigre. Otok sem obiskal dvakrat. 30. 5. 2011 sem med kamenjem naštel 10 gnezd, na podlagi števila ptic, ki so me obletavale, sem ocenil, da jih je bilo takrat na otoku morda celo 15, a vseh nisem našel. V dveh gnezdih so bili sveže izvaljeni mladiči. Ob obisku 22. 5. 2012 sem našel 5 gnezd, na podlagi ptic, ki so me obletavale, pa sem ocenil, da je tisto leto na otoku verjetno gnezdilo do 20 parov čiger. Mladiči se še niso izvalili. Nekoliko stran od kolonije navadnih čiger je bil tudi en par male čigre *Sternula albifrons*, vendar gnezdenja te vrste nedvoumno nisem mogel potrditi.

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Navadna čigra *Sterna hirundo*

Common tern – in 2017, at least 18 breeding Common Tern pairs started to nest in the Ulcinj Salina. Due to constant changes in the water level, not a single egg hatched.

Med 22.5. in 1.6. 2017 sem na Ulcinjskih solinah preštel 54 navadnih čiger in našel 18 gnezd z valečimi pticami, večinoma na solinskem polju 31 in na Jezeru 1. V dneh med 19. 6. in 22. 6. je bilo solinsko polje 31 povsem brez vode, gnezda čiger so propadla. Na Jezeru 1 je bilo še 7 gnezd. Kasneje so s povišanjem vodostaja zaradi črpanja morske vode, propadla tudi ta gnezda. Od skupaj najmanj 18 gnezd v letu 2017 torej ni bilo uspešno nobeno. Po propadu gnezd so čigre iz območja izginile, tako da nadomestnih ni bilo. Starejša poročila za to območje govorijo o 30 do 80 gnezdečih parih navadne čigre v obdobju 2003 do 2006 (Štumberger in sod. 2008) in 5 do 10 parih v letu 2015 (Schwarz in Sackl 2017), nič pa ni objavljenega o tem, koliko gnezd je bilo uspešnih.

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DRUGE ČIGRE / OTHER TERNS

Whiskered Tern *Chlidonias hybrida*

Belolična čigra – največje zabeleženo število na eni lokaciji v Sloveniji: 74 in 86 osebkov v parih dne 17. in 18. 5. 2009 na Ptujskem jezeru. Zaradi majhne oddaljenosti najbližjih gnezdišč v sosednjih državah in gnezditvenih navad vrste takšna opazovanja na panonskem delu Drave niso povsem nepričakovana.

Whiskered Tern occurs on regular basis at large reservoirs in the Pannonian part of the Drava River in Slovenia (NE Slovenia). In a decade of systematic waterbird counts (2009–2018) the species was registered in most 10-day periods between mid-April and early July, while observations are somewhat less frequent during the summer months (N = 102 records). Most records include small groups, with few observations of more than 20 individuals at one site in a single count (*own unpubl. data*). Thus, the following observations deserve special mentioning: at Lake Ptuj, 74 and 86 individuals were counted on 17 and 18 May 2009, respectively. Birds were obviously paired and very active, constantly flying around in twos low above the water surface of the widest section of the reservoir. In days prior and after this observation, no Whiskered Terns or only small numbers were present at the site. This is by far the highest number of individuals registered during a single count on the Drava River, with no similar records existing elsewhere in Slovenia as well as Austrian Styria (e.g. Bordjan & Božič 2009, Bordjan 2012, Albegger *et al.* 2015). Even at well-watched and internationally important Lake Neusiedl, the largest flock of migrating Whiskered Terns registered in the years 1992–2009 was substantially smaller (22 ind.) (Dvorak *et al.* 2010). However, occasional occurrence of significant numbers along the lower Drava in Slovenia is not completely unexpected due to proximity of the nearest nesting sites in neighbouring regions of Croatia and Hungary (< 100 km). Whiskered Terns are known for their erratic breeding and can greatly delay egg-laying dates in the case of unfavourable conditions at nest sites (Paillisson *et al.* 2006).

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Sandwich Tern *Sterna sandvicensis*

Kričava čigra – dne 20.10.209 je med našim rednim monitoringom na obali pri kraju Privlaka (SZ Dalmacija, Hrvaška - UTM WK10) počivala jata 110 kričavih čiger. Kričava čigra je ob hrvaški obali Jadrana redna preletnica in prezimovalka, a to je bila največja doslej opažena jata.

In the period between September 2018 and April 2019, regular monthly bird counts were carried out in shallow bays and other coastal habitats of northwestern Dalmatia and the island of Pag. The small shallow bay near the town of Privlaka (UTM WK10), situated between the promontories of Soline and Kulina and the islet Školjić, proved to be an important roosting site for the Sandwich Terns during the autumn of 2018. We observed 15 ind. on 18 September 2018 and 110 ind. on 20 October 2018, while no birds were present in November. During the winter months (December-February), only 2–6 ind. per day were observed in the area. On 14 March 2019, only one bird was present and no birds were seen in April. According to these data, Privlaka is an important stopover site for Sandwich Terns during autumn migration with high peak recorded in October. These results are in line with the data collected from 1984 to 1997 along the entire Adriatic coastline in Croatia (Stipčević *et al.* 1998). In this study the bay near Privlaka had been identified as the most important gathering site of Sandwich Terns on the Croatian coast, with the peak of autumn and spring migration in October (max 74 ind.) and March (max 40 ind.), respectively. Ringing recoveries suggest that birds gathering at Privlaka most probably originate from breeding colonies in the Black Sea and northeast Italy (Kralj 2013). It appears that the birds roosting during autumn near Privlaka either leave the Adriatic or scatter throughout the coast, since only smaller flocks (usually up to 10 ind.) can be seen in the wider area in

Figure 4 / Slika 4: Roosting of Sandwich Terns *Sterna sandvicensis* in shallow bay near Privlaka / Jata kričavih čiger pri počitku na obali zaliva pri Privlaki (foto: A. Tomik)

the winter period. During early spring of 2019 we did not observe any big flock of Sandwich Terns in the area between Privlaka and Nin, whereas Stipčević *et al.* (1998) had recorded maximum counts of 40–48 birds per year in this area. Along the Croatian coastline the Sandwich Tern is a regular species during the migration and wintering periods with recorded numbers ranging between 1–74 ind./day/locality (Stipčević *et al.* 1998). Besides the Privlaka-Nin area, the only major gathering site of the species is the mouth of the Neretva River in southern Dalmatia with counts of up to 38 ind. (Ilić 2018). Thus, the 110 ind. of Sandwich Terns observed on 20 October 2018 near Privlaka (Figure 1) represent a new record number of birds seen together in one place.

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Gull-billed Tern *Gelochelidon nilotica*

Črnonoga čigra – en osebek opažen 13. 7. 2018 na Dravi na otočku pri vasi Repaš (Hrvaška)

In the breeding season 2018, we monitored Common Terns *Sterna hirundo* along the Drava River in Croatia. On an islet near the bridge in the village of Repaš, Common and Little Terns *Sternulla albfrons* started to breed, but most of the pairs failed to produce any offspring; we found only one successful nest of the Little

Figure 5 / Slika 5: Gull-billed Tern among Common Terns near the village of Repaš (Croatia) / Črnonoga čigra med navadnimi čigrami pri naselju Repaš (Hrvaška) (foto: G. Šafarek)

Figure 6 / Slika 6: One of four Gull-Billed Terns roosting at Malo Blato on Pag Island (Croatia) / Ena med štirih črnonogih čiger pri počitku pri Malem blatu na Pagu (Hrvaška) (foto: T. Klanfar).

Tern and none of the Common Tern. On the last field day, 13 July, we saw one adult Gull-billed Tern resting between Common and Little Terns on the islet. The Gull-billed Tern is irregular on migration in Croatia (more often in spring), seen more often on the coast than in the continental part of Croatia (Kralj 1997).

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Gull-Billed Tern *Gelochelidon nilotica*

Črnonoga čigra - štirje osebki opazovani 22. 5. 2019. pri Malem Blatu na otoku Pagu (UTM WK01, S Dalmacija, Hrvaška). Tretja jata po velikosti opazovana na Hrvaškem in najštevilčnejša opazovana na otoku Pagu.

On 22 May 2019, I visited Malo Blato marsh located near Povljana on the island of Pag. Slowly driving along the road located between the marsh and the adjacent seacoast I noticed four individuals of Gull-Billed Tern roosting on stones protruding from the sea along the coast. When I stopped at the roadside to get a better look at them, they were flushed and started to fly around and forage along the coast as well as along the channel connecting Malo Blato with the sea. During the foraging activities, which lasted for more than 30 minutes, the birds fed on items caught on the sea surface and, at times, in the air. After the period of foraging, all four individuals settled near their previous roost site.

The Gull-Billed Tern is a regionally extinct breeder and irregular migratory species in Croatia (Tutiš *et al.* 2013). Commonly, individual birds have been observed (Kralj 1997), rarely up to two individuals (Ploj & Novak 2014), and only exceptionally six and ten individuals (Dumbović Ružić & Štumberger 2002, Mikuska *et al.* 2003)

Spring migration of the species occurs from April to May (Cramp 2006), which makes the observation described above as a late one in the spring migrating season.

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Whiskered Tern *Chlidonias hybrida*

Belolična čigra – pozno gnezdenje na ribnikih Pisarovina (Hrvaška)

Whiskered Terns usually nest on fish ponds of continental Croatia, including the westernmost fish ponds: Crna Mlaka, Lipovljani, Poljana, and sometimes Pisarovina. After 2015, the fish farming company Pisarovina has changed its owner, and it is only then that fundamental reforms like the rearranging of fishing plots and levees have occurred. In that period, the fish pond was also fenced off. The setup of these new arrangements ended in 2018. The following returning species were recorded: more than a few species of Warblers (*Acrocephalus schoenobaenus*, *Acrocephalus scirpaceus*), Night Heron *Nycticorax nycticorax*, Purple Heron *Ardea purpurea*,

Figure 7 / Slika 7. Whyskered Terns with three hatchlings on 15 August 2019 / Beloličnа čigra s tremi mladiči, fotografirana 15. 8. 2019 (Foto: D. Krnjeta)

Little Egret *Egretta garzetta*, Grey Heron *Ardea cinerea*, Mallard *Anas platyrhinchos*, and Ferruginous Duck *Aythia nyroca*. After them, other usual species have returned as well.

Croatia boasts between 1600–2700 nesting pairs of Whiskered Tern. They start with their nesting in the beginning of June. The nest is being continuously built until the end of the same month (on 26 June 2010, the Poljana fish pond had more than 150 nesting pairs, while on 10 June 2011 between 80–100 nesting pairs were recorded at the Lipovljani fish pond) (Kralj *et al.*, 2013).

On 11 May 2019, eight Whiskered Terns were seen flying over the Pisarovina fish pond, where they would return in the middle of July when they begin building their nests amidst the *Nymphacea spp.* plants. Between 25 and 30 pairs were recorded. First hatchlings emerged from the eggs around 5 August. Four surveilled nests contained three chicks in each nest. The nests were constantly repaired with aquatic vegetation, and the chicks were fed by one member of the pair, while the other one was perching on a nearby pillar and visibly reacting to specific occurrences considered by it to be unpleasant and hazardous for the chicks (such as Marsh Harriers *Circus aeroginosus* flying over the pond, the presence of Black-Headed Gulls *Larus ridibundus*, as well as other Whiskered Terns appearing in the vicinity of the nest). Separate Whiskered Terns can be distinguished by white stains which are mottled on their dark forehead. The main reason for such a late nesting in the season is unknown, but it can be safely assumed that the first nesting attempt had failed. At the beginning of September, the colony was abandoned, and the Whiskered Terns that were nesting that year were not noted on the fishpond anymore.

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General remarks:

Manuscripts should be edited in Microsoft Word or OpenOffice.org (DOC or DOCX format), the font should be Times New Roman, size 12pt and formatted in single spacing. Send figures separately from the manuscript in TIFF or JPG formats with a resolution of at least 300 dpi. For vector graphics EPS and CDR are preferred. Send tables and graphs in XLS format, each in a separate worksheet of the same XLS document. Titles and legends of tables and graphs should be included both in the manuscript and the XLS document. English bird names should follow Svensson *et al.* [Svensson L. Mullarney K., Zetterström D. (2009): Collins Birdguide. 2nd Edition. – HarperCollins, London]. Scientific bird names should follow recommendations of the British Ornithologists' Union Records Committee Taxonomic Sub-committee [http://www.bou.org.uk/british-list/bourc-reports-and-papers]. Slovene bird names should follow Jančar *et al.* [Jančar T., Bračko F., Grošelj P., Mihelič T., Tome D., Trilar T., Vrezec A. (1999): Imenik ptic zahodne Palearktike. – Acrocephalus 20 (94/96): 97–162].

Format of original articles submitted for publication

The manuscript should be headed by the title, article type, names of authors, their affiliation and e-mail addresses. If the first author is not the corresponding author, this should be indicated.

Abstract: It should present the aims, methods, main results and conclusions in no more than 250 words. References and abbreviations should not be used in the abstract.

Key words: Give up to 8 keywords separated by commas. Choose them carefully, because they serve indexing purposes and enable readers to find your paper in online databases.

Main text: The IMRAD structure (Introduction, Methods, Results, Discussion) should be followed. Scientific names in italics should be given in the title (if appropriate), at the first mention of the species in the abstract and at the first mention in the main text.

References should be cited in alphabetical order and, for the same author, in chronological order. If the author published more than one work in the same year, a small letter is added to the year (e. g. Tome 1990a). In the text, references are cited as Howell (2012) or (Howell 2012), as appropriate. Works written by two authors are cited as (Bordjan & Božič 2009), those by more than two authors as (Bordjan *et al.* 2013). Citing unpublished data should be avoided as much as possible, these references should only be mentioned in the main text, not in the list of references. Citing of papers in preparation is only allowed if they are already accepted for publication. References should be cited in the following style:

journal paper: Petkov N. (2011): Habitat characteristics assessment of the wetlands with breeding Ferruginous Duck *Aythya nyroca* and Pochard *A. ferina* in Bulgaria. – Acrocephalus 32 (150/151): 127–134.
book: Balmer D. E., Gillings S., Caffrey B. J., Swann R. L., Downie I. S., Fuller R. J. (2013): Bird Atlas 2007–11: The Breeding and Wintering Birds of Britain and Ireland. – BTO Books, Thetford.
chapter in book: Diedrich J., Flade M., Lipsbergs J. (1997): Penduline Tit *Remiz pendulinus*. pp. 656–657. In: Hagemeijer W. J. M., Blair M. J. (eds.): The EBCC Atlas of European Breeding Birds. – T & AD Poyser, London.
short note: Ernst S. (2013): Pygmy Owl *Glaucidium passerinum*. – Acrocephalus 34 (156/157): 131–132.
conference proceedings: Vrezec A. (2007): The Ural Owl (*Strix uralensis macroura*) – status and overview of studies in Slovenia. pp. 16–31. In: Müller J., Scherzinger W., Moning C. (eds.): European Ural Owl workshop: Bavarian forest national park. – Graphischer Atelier H, Prague.
dissertation or thesis: Ličina T. (2012): [Predation of eggs in artificial ground bird nests in forest in the area of Menina mountain]. BSc thesis. – Univerza v Ljubljani, Biotehniška fakulteta, Oddelek za biologijo. (in Slovene)
web source: Zois, S. (1790/1800): Aves terrestres Europae. – [http://www.dlib.si/details/URN:NBN:SI:DOC-YJ3DA9MZ], 01/05/2014.
legislation: Uradni list RS (2011): Uredba o Načrtu upravljanja Krajinskega parka Sečoveljske soline za obdobje 2011–2021. No. 53/2011.

Titles of works, published in languages other than English or Slovene, should only be translated if a translated title is supplied with the original work. For example:

Montadert M., Léonard P. (2011): [Breeding biology of Hazel Grouse *Bonasa bonasia* in the South-Eastern French Alps (1^{st} part)]. – Alauda 79 (1): 1–16. (in French)
Titles, originally in a script other than Latin, should be latinized even if the original language is preserved.

Tables should be headed by an informative title and a brief explanatory legend, enabling the reader to understand the general meaning without referring to the main text. Tables are drawn without vertical lines and referred to as, e. g. "Table 1" in the text.

Figures: Titles should be given below the figures. They are referred to as, e. g. "Figure 1" in the text.

Format of other sections

Review articles and points-of-view should follow the same general rules as original articles, but the titles of sections may be adapted to the content.

Short communications should follow the general rules of original papers, but the authors are free to determine its structure.

Forum: The author of the comment is allowed one comment, to which the author of the original article can reply in the same issue.

Short notes "From the ornithological notebook": The title is the name of the species. A short abstract should give the date of observation, observation site with coordinates (UTM, degrees or Gauss-Krüger) and summarize the note. In the text, references are cited as Snow & Perrins (1998) or (Snow & Perrins 1998) as appropriate. Short notes should be submitted in separate files, one note per file.

Special abbreviations used in text: English: *pers. comm., unpubl., own data, in print, in prep.*; Slovene: *pisno, ustno, neobj., lastni podatki, v tisku, v pripravi.*

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